HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE MANUAL

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BRIAN GALLANT

WILEY-INTERSCIENCE

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FOREWORD

The writing of this book was a major undertaking. It was a lifelong dream to author a text, but I had no idea of the number of hours involved and the sacrifices that many others had to endure to make this happen.

Several people assisted me with this endeavor and I wish to thank them for their encouragement, support, and patience. You all know who you are and, at the risk of leaving a name out, I am not going to list everyone. I hope you understand.

To my students, former and current, thank you all. I want each of you to know that I learned from you as well and there was rarely a class that went by that I didn't pick something up from you.

There is, however, one person that without her help this would not have been possible. Her understanding and love has been an inspiration to me. My wife, Heather, has been my sounding board, loudest critic, and biggest supporter. She always has some words of wisdom for me and has sacrificed more than I have during this process. For all of these things, I want to thank her from the bottom of my heart. Honey, you're the best! Without you, I could not have completed this task.

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by Brian J. Gallant

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REGULATIONS, AGENCIES, AND RESOURCES

INTRODUCTION—HISTORY OF EMPLOYEE HEALTH AND SAFETY REGULATIONS

Employee health and safety regulations in place in today's work environment stem from the end of the 1800's and the mining industry. Due to the high fatality record among mine workers, a series of laws was established to address the issue in approximately 1870. After the Second World War, health and safety laws grew to encompass many other industries. It wasn't until 1970, when the United States Congress adopted the Occupational Safety and Health Act (OSHAct,) that specific laws were enacted to protect worker health and safety. Additionally, the Occupational Health and Safety Administration (OSHA) was created. OSHA has the authority to enforce these health and safety standards in the workplace.

Figure 1.1 OSHA Logo

Regulations

Prior to 1970, effective workplace safety and health regulations did not exist on either federal or state levels. The regulations that did exist were not enforced. Therefore, large numbers of workers experienced illness, injury, and death as a result of unsafe and unhealthy working conditions. In addition to occupational health and safety concerns, our country was struggling with environmental management of industrial chemical use, disposal, and pollution issues.

In 1970, Congress established the Occupational Safety and Health Administration to ensure safe and healthful work environments in the manufacturing and construction industries. At the same time, The Environmental Protection Agency (EPA) was instituted to oversee resource management. Today, OSHA is the primary guardian of worker's health and safety standards. EPA continues to protect the public's health, along with regulating the cleanliness and safety of our lands, air, and water.

All employees need to have a basic understanding of the laws and agencies that help regulate hazardous operations. Understanding the laws and rules that stipulate the requirements and restrictions for working in hazardous environments and/or conditions requires familiarity with the evolution and interface of the federal acts and agencies that contain the laws. Many other local, state, and federal entities play a key role, in addition to the EPA and OSHA, in writing and enforcing regulations that affect hazardous material operations, and, in particular, waste sites.

The following is a list of federal agencies that regulate the organizations that are engaged in hazardous waste operations:

- Environmental Protection Agency
- Department of Labor—Occupational Safety and Health Administration
- Department of Transportation

Workers should also keep in mind that state and local governments also have regulatory agencies that could have some jurisdiction over hazardous waste operations. If there are questions regarding who has the authority, you should consult your local authorities for further information.

THE ENVIRONMENTAL PROTECTION AGENCY

The EPA governs the quality of our environment, including air, land, and water. In addition, EPA administers the regulations that manage hazardous waste. EPA played a vital role in spearheading the Hazardous Waste Operations and Emergency Response (HAZWOPER) regulations that are currently in existence for worker safety at hazardous waste sites.

These are a few of the parts of the EPA regulations noting where some significant environmental acts are incorporated into the regulations. EPA regulations are found in the Code of Federal Regulations (CFR) in 40 CFR:

- 40 CFR 50-99 Clean Air Act
- 40 CFR 100-140 and 400-470 Clean Water Act
- 40 CFR 240-271 Resource Conservation and Recovery Act (RCRA)
- 40 CFR 260-299 Hazardous Waste Management System
- 40 CFR 279 Used Oil Management Standards
- 40 CFR 700-799 Toxic Substance Control Act (TSCA)

Figure 1.2 EPA Logo

Hazardous wastes are identified by the EPA as described in 40 CFR 261. Listed wastes are known waste streams generated by specific processes. According to RCRA, if a waste is not listed, it must be tested to see if it exhibits one or more of the following characteristics. Wastes that exhibit these characteristics are called characteristic waste:

- Ignitable—waste having a flash point of < 140 degrees F, or an ignitable compressed gas, flammable liquid or solid, or oxidizer according to DOT
- Corrosivity—waste with a pH of <2.0 or >12.5
- Reactive—wastes that explode or react violently when exposed to water, or that generate toxic gases
- Toxic—waste analyzed using the Toxic Characteristic Leachate Procedure (TCLP) test to check for toxic constituents at levels greater than those specified in the applicable environmental regulations

Hazardous Waste Numbers

A four digit number is given to different wastes by the EPA for identification purposes. They are:

- D001- Ignitable Wastes
- D002- Corrosive Wastes
- D003- Reactive Wastes

TABLE 1.1 Table 1.1 outlines some of the EPA levels.

Toxin	US EPA Limits
Arsenic	5.0 ppm
Cadmium	1.0 ppm
Chromium	5.0 ppm
Lead	5.0 ppm
Mercury	.02 ppm

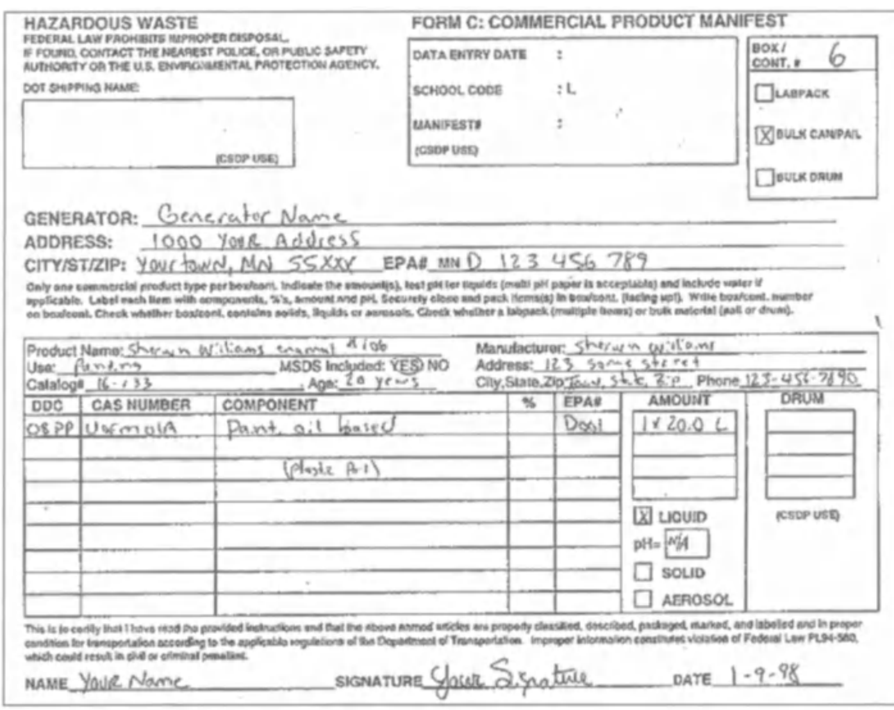
- D004-D043- Toxic Wastes
- D008- Lead
- D018- Benzene
- D019- Carbon Tetrachloride

EPA Identification Numbers

A unique EPA twelve digit number is assigned to each waste generator, transporter, and Treatment, Storage, and Disposal Facility (TSDF). The EPA assigns an identification number to each of these entities for tracking purposes. These numbers are put onto a Hazardous Waste Manifest Form.

Clean Water Act

The Clean Water Act, amended and reauthorized in 1987, has the goal of maintaining or regaining the chemical, physical, and biological integrity of United States' waters. Both the EPA and the Army Corps of Engineers have jurisdiction. The Clean



HAZARDOUS WASTE
FEDERAL LAW PROHIBITS IMPROPER DISPOSAL.
IF FOUND, CONTACT THE NEAREST POLICE, OR PUBLIC SAFETY AUTHORITY OR THE U.S. ENVIRONMENTAL PROTECTION AGENCY.
DOT SHIPPING NAME:
(CSDP USE)

FORM C: COMMERCIAL PRODUCT MANIFEST
DATA ENTRY DATE :
SCHOOL CODE : L
MANIFEST# :
(CSDP USE)

BOX / CONT. # 6
☐ LABPACK
☒ BULK CAN/PAIL
☐ BULK DRUM

GENERATOR: Generator Name
ADDRESS: 1000 Your Address
CITY/ST/ZIP: Yourtown, MN 55XXX EPA# MN D 123 456 789

Only one commercial product type per box/cont. Indicate the amount(s), test pH for liquids (multi pH paper is acceptable) and include water if applicable. Label each item with components, %'s, amount and pH. Securely close and pack items(s) in box/cont. (facing up!). Write box/cont. number on box/cont. Check whether box/cont. contains solids, liquids or aerosols. Check whether a labpack (multiple items) or bulk material (pail or drum).

Product Name: Sherwin Williams enamel #106
Use: Painting
Catalog# 16-133
MSDS Included: (YES) NO
Age: 20 years
Manufacturer: Sherwin Williams
Address: 123 Same Street
City,State,Zip Town, State, Zip Phone 123-456-7890

DDC	CAS NUMBER	COMPONENT	%	EPA#
08PP	Uxmola	Paint, oil based		D001
		(plastic pail)		

AMOUNT: 1 x 20.0 L
☒ LIQUID
pH= N/A
☐ SOLID
☐ AEROSOL
DRUM
(CSDP USE)

This is to certify that I have read the provided instructions and that the above named articles are properly classified, described, packaged, marked, and labelled and in proper condition for transportation according to the applicable regulations of the Department of Transportation. Improper information constitutes violation of Federal Law PL94-580, which could result in civil or criminal penalties.

NAME Your Name SIGNATURE Your Signature DATE 1-9-98

Figure 1.3 Hazardous Waste Manifest Form

Water Act regulates discharge of toxic and non-toxic pollutants into surface waters. The interim goal is to make surface waters usable for such activities as swimming and fishing, with the ultimate goal to eliminate all discharges into surface waters. EPA sets guidelines and individual states issue permits through the National Pollutant Discharge Elimination System (NPDES) specifying the types of control equipment and discharges for each facility.

Figure 1.4 Army Corps of Engineers Logo

Clean Air Act

The Clean Air Act (CAA), reauthorized in 1990, amended the Air Quality Act of 1967. The Clean Air Act is designed to enhance the quality of air resources by authorizing the EPA to set the criteria for our nation's air pollution control programs. The CAA mandates and enforces toxic emission standards for stationary sources (like power plants) and motor vehicles. Air quality standards are required to be achieved and maintained nationwide for six pollutants. Those six pollutants are:

- ozone
- nitrogen dioxide
- carbon monoxide
- sulfur dioxide
- total suspended particulates (TSP)
- lead

Resource Conservation and Recovery Act (RCRA)

In the late 1960s and early 1970s, the Congressional Office of Technology Assessment estimated that between approximately 250 and 275 million metric tons of hazardous waste were produced each year in the United States. Air and ground water pollution, contamination of surface water, and poisoning of animals and humans by way of the food chain supported the EPA's belief that only a small percentage of generated waste was being disposed of in an environmentally acceptable manner.

Congress had generally addressed the problems of solid waste disposal by enacting the Solid Waste Disposal Act in 1965. The first comprehensive Federal effort to confront the problems of solid and hazardous waste began in 1976 when RCRA was enacted. RCRA is an amendment that completely revised the Solid Waste Disposal Act of 1965.

RCRA was established to regulate the management and disposal of hazardous materials and wastes. RCRA gave EPA the jurisdiction and responsibility to create and enforce the regulations governing the proper identification, handling, storing, treating, and disposal of hazardous waste. RCRA instituted the manifest system of tracking a hazardous waste from generator through transportation, storage, and disposal. This is often referred to as "cradle to grave" liability tracking system. It also encourages hazardous waste recycling and minimization.

As of 1983, an estimated forty million metric tons of hazardous waste escaped regulatory control through various loopholes in the legislative framework. RCRA was falling short of its intent, and Congress amended it in 1984. These amendments strengthened RCRA to include underground storage tanks (USTs), redefined small quantity generator (SQG) to include more generators, and restrict liquid and hazardous waste from landfills.

Toxic Substance Control Act

The Toxic Substance Control Act gave the EPA authority to regulate the manufacture, distribution, and use of chemical substances for which there are not specific standards already established. TSCA required EPA to evaluate chemicals before they are sold, to prevent any unreasonable chemical risk to humans or the environment, as well as create a list of reviewed harmful substances that need precautions and safe work practices when used by the general public or industry.

Figure 1.5 Underground storage tank

Comprehensive Environmental Response Compensation and Liability Act (CERCLA)

Enacted to fill a void in the RCRA law, CERCLA addresses problems associated with contamination from abandoned facilities or releases of hazardous substances into the environment from vessels or facilities that are not subject to RCRA authority. CERCLA, better known to most of us as "Superfund," authorizes government money for clean-up of abandoned hazardous waste sites, clean-up and emergency response for transportation incidents involving chemical releases, and payments to injured or affected citizens. This legislation was amended by Superfund Amendment and Reauthorization Act (SARA) in 1986. Superfund:

- Established the National Priority List.
- Provides for identification and cleanup of hazardous waste sites.
- Gets funding to implement these activities from oil tax, waste generator fines, and the United States Treasury (taxpayers).

Superfund Amendment and Reauthorization Act (SARA)

SARA was passed to protect the safety and health of personnel working in hazardous operations, as well as the community at large. First, SARA reauthorized the funding to continue site characterization (assessment) to determine which locations belong on the National Priority List, as well as continuing abandoned site cleanup.

In addition, SARA mandated that the Occupational Safety and Health Administration establish worker safety and health standards for hazardous waste operations and emergency response activities. SARA requires training for both workers and management personnel covering safety and health risks at waste sites, Treatment, Storage and Disposal Facilities (TSDF), and emergency response operations. SARA also initiated the requirement for local and regional emergency contingency planning.

Figure 1.6 Superfund sites like the one shown above are being cleaned up daily.

Three distinct Titles or sections make up SARA. Titles I and III cover hazardous waste operations, emergency response, and planning, while Title II targets a fund for hazardous waste cleanup activities.

Title I:

- Requires training for hazardous waste operation site workers and emergency response personnel (HAZWOPER).
- Requires preparation of a written emergency response plan for operations where hazardous materials may be spilled or released.
- Requires proper procedures for handling emergency response activities.

Title II:

- Gives authority for Superfund to continue to pay hazardous waste clean up through a tax on industry.

Title III (Community Right to Know) was established in large part as a result of the widely published 1984 disaster in Bhopal, India, in which a massive amount of toxic methyl isocyanate escaped from the Union Carbide facility.

- Developed "Comprehensive Community Emergency Plans" by Local Emergency Planning Committees (LEPCs)
- Reported specific chemical inventory and release information to local fire officials, LEPCs, and the State Emergency Response Commission (SERC)
- Facilities storing chemicals provide the chemical types, quantity on hand, and locations with inventory lists; fees are assessed based on substances and quantities involved
- Local fire departments visit facilities to determine hazards and ensure compliance with this Title.

Figure 1.7 Fire Marshal Patch

DEPARTMENT OF LABOR—OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

Under the Department of Labor (DOL), OSHA is the primary federal agency designated to safeguard the safety and health of the nation's workers in any hazardous activity. OSHA sets, oversees, and enforces health and safety standards for workplace safety. The two most important standards OSHA utilizes to protect employees are the Hazard Communication Standard and the Hazardous Waste Operations and Emergency Response Standard.

Individual states, called "state plan states," may write and enforce their own OSHA regulations as long as they are at least as stringent as the federal law.

Figure 1.8 Department of Labor Logo

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

NIOSH is an agency under the Department of Health and Human Services (DHHS) that investigates incidents, researches occupational safety, and recommends exposure limits (RELs) to OSHA for certain hazardous chemicals. The Institute also tests and certifies all respiratory and air sampling devices (except mining devices), as well as recommends assigned protection factors (APF) for respirators. NIOSH does not act in a regulatory capacity at all.

DEPARTMENT OF TRANSPORTATION (DOT)

The DOT oversees the transport of hazardous materials through interstate commerce. The Hazardous Materials Transportation Act (1975) granted the DOT authority to establish criteria for packaging, labeling, placarding and shipping papers necessary to transport hazardous materials; as well as the training of personnel responsible for hazardous material transportation. The Act was reauthorized in 1990, becoming the Hazardous Materials Transportation Uniform Safety Act (HMTUSA).

Figure 1.9 NIOSH Placard

The HMTUSA is the federal transportation act that applies to any person or company that ships hazardous material and/or waste in commerce by air, water, rail, and/or highway. The shipping requirements include preparation of shipping papers or a uniform hazardous waste manifest, pacing the material in specific packages, placing the hazard labels on the packages and placards on the shipping containers.

Figure 1.10 DOT Placard

DOT labels are four-inch diamond shaped, color specific stickers that designate the hazard classification of the packaged material. Labels are used on non-bulk containers, less than or equal to one hundred nineteen (119) gallons or eight hundred eighty two (882) pounds, along with the shipping name and identification number of the substance in the container.

Placards are 10.7 inch square color-specific diamonds used on freight containers, vehicles, and bulk packages, greater than 119 gallons or 882 pounds, in addition to the identification number of the material in the container(s). If necessary, placards are required to be placed on each side and on each end of the freight container(s), vehicle(s), and package(s), for a total of four placards of each type on the container.

Figure 1.11 DOT Label

Both DOT and the United Nations (UN) transportation systems use a four-digit identification number as a reference for substances and materials. If the UN does not have a UN number designated for a material that is considered hazardous under the DOT system, then DOT issues a NA (North America) number. An identification number may be placed in the center of the placard or displayed on packages as part of the hazard identification system. For example, UN 1203 is the identification number for gasoline.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

While the NFPA has several standards they have generated, they are not a regulatory or governmental agency. They are a private international group, based in Massachusetts. Of particular note to us in the hazardous material field are these standards:

- NFPA 704 Labeling
- NFPA 472 Professional Competency of Responders to Hazardous Material Emergencies
- NFPA has many others that may have applicability to hazardous materials, but the above two are most noteworthy.

Figure 1.12 Gasoline Placard—Note the hazard class (three) shown in the lower point of the diamond.

While the NFPA plays a crucial role in establishing codes and standards on an international basis, they are not a governmental or a regulatory agency. Their codes and standards are strictly voluntary, however, many jurisdictions have adopted them and then they become enforceable.

NFPA 704 Labeling

The 704 standard addresses the health, flammability, instability (reactivity), and related special hazards that may be presented by short-term, acute exposure to a material during handling under conditions of fire, spill, leak, or similar emergencies. It provides four pieces of information to workers and also instructions for a simple, readily recognized, and easily understood system of markings that provides a general idea of the hazards of chemical materials stored and/or used in an area or space (such a warehouse or storage facility). The severity of these hazards as they relate to handling, fire prevention, exposure, and control is also included.

The hazard ratings reflect the acute effect of a chemical material which involve short-term (minutes or hours), high concentrations and immediate deleterious health effects (e.g., severe burns, respiratory failure, coma, death, and irreversible damage to a vital organ). Acute exposures are usually related to an accident such as a chemical spill, massive skin splash and fire. Acute exposures, typically, are sudden and severe, and are characterized by rapid absorption of the chemical that is quickly circulated through the body and damages one or more of the vital organs.

The objectives of the NFPA 704 labeling system are:

- To provide an appropriate signal or alert and on-the-spot information to safeguard the lives of emergency response personnel (e.g., fire fighters, HAZMAT responders, site workers).
- To assist in planning effective fire and hazardous material emergency control operations, including clean up activities.
- To assist all designated field personnel, engineers, equipment operators and safety personnel in evaluating hazards.

The NFPA 704 diamond system is intended to provide basic information to fire fighting, emergency and other personnel, enabling them to more easily decide whether to evacuate the area or to commence emergency control procedures. It is also intended to provide them with information to assist in selecting fire fighting tactics, appropriate personal protective equipment, and emergency procedures.

How is the degree of hazard severity positioned and indicated to reflect potential acute health and/or safety hazard? The NFPA 704 sign (label) consists of four diamonds within a larger diamond. The red, flammability diamond is at "12 o'clock"; the yellow, instability diamond is at "3 o'clock"; the white, special hazards diamond is at "6 o'clock" and the blue, health hazard diamond is at "9 o'clock".

The degree of hazard severity for a chemical liquid or solid—flammability, health hazard, instability (reactivity) is indicated by a numerical rating that ranges from four (4), indicating the most severe hazard to zero (0), indicating no significant hazard.

Special hazards are indicated in the white section that is located in the lower region of the 704 sign. There are two special hazard categories:

- Water reactive—Chemicals that demonstrate unusual reactivity with water are designated by the letter W with a horizontal line through the center ~~**W**~~.
- Oxidizers—Chemicals that decompose readily under certain conditions to yield oxygen are designated by the symbol **OXY**. They may cause a fire in contact with combustible materials, can react violently with water and when involved in a fire can react violently.

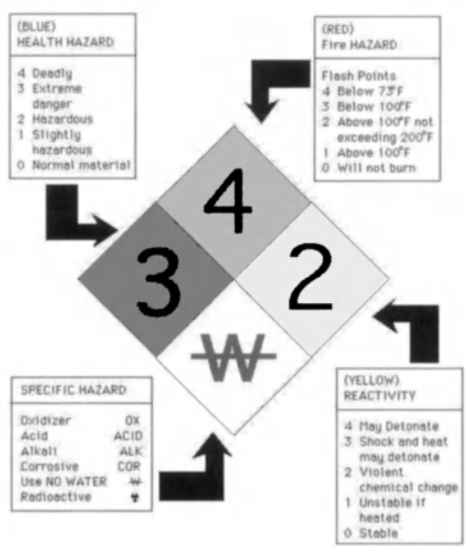


Figure 1.13 NFPA Label—This NFPA label outlines the four categories and shows what the numbers mean.

- You may also see other symbols such as the skull and crossbones for a poison, the radioactive symbol for a radioactive material, etc.
- This section will not have number, but instead will feature a symbol or letter to indicate if any special hazard is present

Hazard Communication Standard

The Hazard Communication Standard (Haz Com) or Right to Know Law was enacted in 1980. It is also referred to as 29 CFR 1910.1200. The Haz Com Standard requires the following:

- Manufacturers and/or importers of chemicals to evaluate the hazards
- Chemical hazards information be passed on to employees who have to work with these substances
- Employees to know and understand the chemical and physical hazards present in their work environment

The Hazard Communication Standard also addresses five major topic areas:

- Hazard Determination
- Written Hazard Communication Program

- Labels and other forms of warning
- Material safety data sheets (MSDS)
- Employee information and training

Hazardous Waste Operations and Emergency Response (HAZWOPER)

The HAZWOPER regulation (also known as 29 CFR 1910.120) became effective on March 6, 1989, just eighteen days prior to the Exxon Valdez oil spill in Prince William Sound, Alaska. HAZWOPER requires stringent health and safety programs for hazardous waste operations and emergency response operations, as well as quantity and content of the training that must be provided to anyone who may be exposed to a hazardous waste or material in the workplace.

Contrary to popular belief, HAZWOPER is not just a training regulation. The following sections are also part of the standard:

- Scope, Application and Definitions
- Safety and Health Program
- Site Characterization
- Site Control
- Training
- Medical Surveillance
- Engineering Controls and Personal Protective Equipment (PPE)
- Monitoring
- Informational Programs
- Handling Drums and Containers
- Decontamination
- Emergency Response
- Illumination
- Sanitation at Temporary Work Places
- New Technology Programs

Hazwoper Training

The Hazwoper Standard is, in my opinion, the most unique OSHA regulation that has been enacted. I say that it is unique from two perspectives. They are:

- Two training requirements in the one OSHA standard
- Specification of number of hours for training personnel

Just about everything that OSHA deals with, has a training implication associated with it. As examples, if you operate a forklift, wear a respirator, or enter a confined space (to name a few things), OSHA requires the employee to be trained. In most of the regulations, it states the employer is responsible for training the worker in the particular subject matter or it states that the employee will be trained. None of the OSHA regulations (with the exception of the asbestos standard, which, for the most part, EPA enforces) gives any time frame for the training except Hazwoper.

The regulation breaks the training down into two sections. Those are:

- Hazardous Waste Operations
- Emergency Response

The training in the hazardous waste operations section is further broken down as follows:

- General Site Workers
- Occasional Site Workers
- Supervisors

OSHA also has training requirements for the Emergency response workers. They include these categories:

- First Responder Awareness—Recognizes and identifies hazards and initiates the response plan. Employees cannot take actions to deal with spill, leak or release.
- First Responder Operations—Employees can take defensive actions to protect nearby personnel, property and the environment, without putting themselves at risk.
- Hazardous Material Technician—Employees can take offensive, aggressive action to stop a release and contain and control emergency situations. When it comes to emergency response, these folks are the "gurus."

TABLE 1.2 Worker training requirements for the Hazardous Waste Operations workers.

General Site Worker	Occasional Site Worker	Supervisor
40 hours training, and 24 hours on the job training under a qualified supervisor	24 hours training, and 8 hours on the job training under a qualified supervisor	8 hours in addition to either the General or Occasional Site Worker Training, depending on who you are supervising
Annual Refresher Training	Annual Refresher Training	Must refresh the General or Occasional Site Worker Training No Supervisor Refresher

- Hazardous Material Specialist- Individuals with specialized training or experience in a specific discipline necessary to properly mitigate the response. Often, these individuals act as liaisons.
- Incident Commander- These are generally the senior officials on the scene, and usually have the highest training (not necessarily). OSHA states that if you are going to take any action at a spill, leak or release, then you must have someone in charge. This is that person.

Please note that the emergency response training requirements do not satisfy the hazardous waste operations requirements and vice versa. Table 1.3 highlights the training requirements for the emergency response personnel.

TABLE 1.3 Emergency Response Training Requirements

Level	Requirement
First Responder Awareness	No specific hours
First Responder Operations	Minimum of 8 hours
Hazardous Material Technician	Minimum of 24 hours
Hazardous Material Specialist	Skills and knowledge of Hazardous Material Technician and/or education and experience
Incident Commander	8 hours in addition to at least 24 hours of training at the Operations level

Incident Command System (ICS)

The Incident Command System is a preplanned chain-of-command used during emergency response. ICS is usually an interface of federal, state, local and private industry personnel fulfilling designated roles. Preplanning, training and practice are required to ensure that everyone knows his/her role within the ICS structure. ICS consists of the following five areas of responsibility:

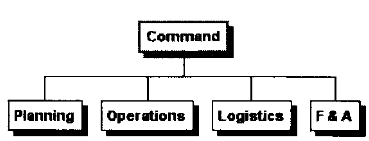


Figure 1.14 This chart indicates the five key areas of the Incident Command System (ICS)

- Operations
- Logistics
- Planning
- Finance
- Command

The number of people involved and the roles of each vary depending upon the type and nature of the emergency. The duties and actions of each member of the ICS require specialized training, which is outside the scope of Hazwoper.

RESOURCES

Hundreds, perhaps thousands, of publications and reference documents containing information outlining the characteristics of hazardous substances are available from a variety of sources. Most, if not all, of the agencies we have discussed earlier have reference texts or databases available. Remember that no reference guide has all of the hazardous materials known to man listed. We'll discuss a few of them further.

Some of the more helpful reference materials include the following:

- Material Safety Data Sheets (MSDS)
- NIOSH Pocket Guide to Chemical Hazards
- Emergency Response Guidebook
- Chemical Hazard Response Information System (CHRIS) Manual

Material Safety Data Sheets (MSDS)

MSDS came about as a result of the Hazard Communication Standard that we discussed earlier in this chapter. It requires all firms manufacturing and/or distributing chemicals for use in the United States to prepare MSDS for those chemicals and distribute them to their customers (us).

The law further requires that employers provide their employees with an MSDS for every hazardous chemical that is present in the workplace. The MSDS is one of those items that are very functional, especially in the event of an emergency. It can actually save your life! The purpose of the MSDS is to inform you about the hazards associated with the chemical you might be working with at your next site. The law says that you must have access to the MSDS and be taught how to read and understand them.

The information that is printed on the MSDS is a summarization of the technical data from many sources. Training, knowledge, and understanding of this technical information will provide workers with the skills to safely deal with any occupational exposure that may arise. Each MSDS is different, so the time to read and understand

Material Safety Data Sheet
May be used to comply with
OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Standard must be consulted for specific requirements.

U.S. Department of Labor
Occupational Safety and Health Administration
(Non-Mandatory Form)
Form Approved
OMB No. 1218-0072

IDENTITY *(As Used on Label and List)* **SALT-X®**	Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.

Section I

Manufacturer's Name **Innovative Chemicals Inc.**	Emergency Telephone Number **704-331-0825**
Address *(Number, Street, City, State, and Zip Code)* **P.O. Box 2826**	Telephone Number for Information **800-827-2189**
Matthews, NC 28106	Date Prepared **November 1999**
	Signature of Preparer *(Optional)*

Section II - Hazard Ingredients/Indentity Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% *(Optional)*
NONE				
(NOT REGULATED BY RCRA)				

Section III - Physical/Chemical Characteristics

Boiling Point	232°F	Specific Gravity (H_2O=1)	1.09
Vapor Pressure (mm Hg.)	UNKNOWN	Melting Point	N/A
Vapor Density (AIR = 1)	UNKNOWN	Evaporation Rate (Butyl Acetate = 1)	SLOWER
Solubility in Water	COMPLETE		
Appearance and Order	CLEAR LIGHT BLUE LIQUID WITH NO DISTINGUISHABLE ODOR		

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used) NONE	Flammable Limits N/A	LEL N/A	UEL N/A
Extinguishing Media N/A			
Special Fire Fighting Procedures N/A			
Unusual Fire and Explosion Hazards NONE			

(Reproduce Locally) OSHA 174, Sept. 1985

Figure 1.15 A sample MSDS is shown above. MSDS are excellent reference guides.

is before you have to use it in an emergency situation. The MSDS tells workers the following:

- Name of manufacturer/distributor; address and phone
- 24 hour contact information
- Ingredients and physical properties of the materials
- Health effects
- Personal protective equipment needed for handling
- First aid treatment if you become exposed
- How to handle an accidental spill or leak
- Firefighting information
- Precautions for safe handling and use
- If the material is a carcinogen (cancer causing)

An understanding of how best to interpret the information from an MSDS is one of the best tools you can have. Knowing what information is on the sheet and where it's located is extremely helpful in an emergency. Remember that the format is different from MSDS to MSDS, so they are not all set up alike. If you encounter a mate-

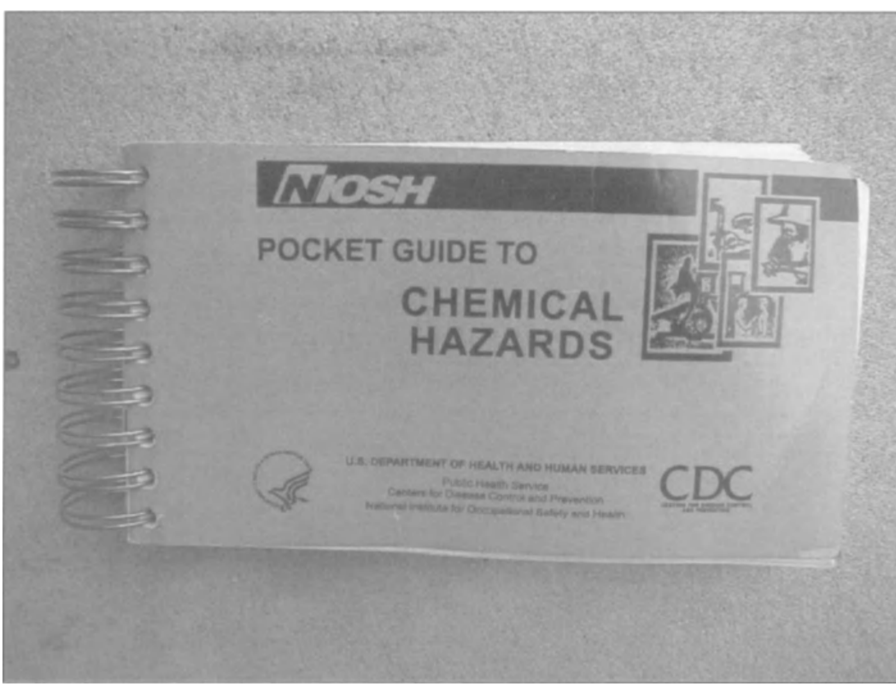


Figure 1.16 The NIOSH Pocket Guide is another reference tool that workers have available to research various chemical hazards in the workplace.

rial you are not sure about, read the MSDS and familiarize yourself and your co-workers with the information and precautions you may have to take.

MSDS were once a two page document. Now I commonly see MSDS that are fifteen or more pages in length. They are only as good as the information that is provided to you. You have to use them to become familiar with the materials you'll encounter on the job. Don't wait until it's too late.

NIOSH Pocket Guide to Chemical Hazards

This book is helpful for identifying chemical and physical properties, personal protective equipment and known health hazards for workers that work with hazardous materials. The hazardous substances are listed in the Chemical Listing section, in alphabetical order along the left hand margin. Several other columns use tables of codes and abbreviations to cross reference, clarify or expand information shown in the column. Tables of codes and the abbreviations are defined in the front of the book. The information provided is very specific about each hazardous chemical listed.

Emergency Response Guidebook

The Emergency Response Guidebook is published every 3 years, or so, by the Department of Transportation. It is a "first aid tool only," in my opinion. It is not going to solve the world's environmental problems; rather it is designed to give guidance to first responders during the initial stages of a hazardous material emergency.

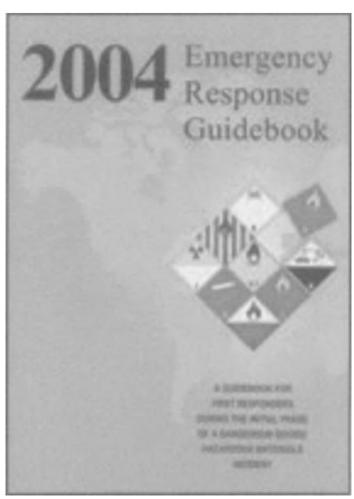


Figure 1.17 The 2004 Emergency Response Guidebook is designed for first responders during the initial phases of a hazardous material incident and is also helpful at hazardous waste sites to aid in identifying materials.

Nothing in the book (for any of the hazardous materials listed) is specific about any of the chemicals. Therefore, not everything in the book about the chemical you look up may be true! This won't get you into trouble, but instead will make you more cautious than you might have to be, considering the situation.

Once you use this tool, I would recommend another reference text or MSDS be used for specific information. This book should not be used to determine compliance with the hazardous materials regulations or to develop safety plans. The reason I say that is that there is nothing specific in the book and this is not what the book is designed for. This is an excellent reference text, but is only one weapon in the arsenal.

Summary

Regulations, the agencies that enforce them and references are all key components in the Hazwoper Training Program. Individuals working with hazardous materials must have a professional, responsible and mature attitude. Your overall goal at the start of each work shift should be to take the necessary precaution to ensure that you return home safely. Using the OSHA standards and the reference texts described, as well as others that you or your company may have will assist you in meting this important daily goal. If you are not sure of the regulations or have a question regarding anything safety related, please ask your supervisor or consult with a safety professional.

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE MANUAL
by Brian J. Gallant

2

HAZARD CLASSIFICATION

Hazardous waste sites pose a whole host of health and safety concerns, any one of which could result in serious injury or even death to a worker or workers. These hazards are a function of the nature of the site, as well as, a consequence of the actual work being performed. They include, but are certainly not limited to the following:

- Chemical exposure
- Fire and explosion
- Oxygen deficient atmosphere
- Ionizing radiation
- Biologic hazards
- Safety hazards
- Electrical hazards
- Heat stress
- Cold exposure
- Noise
- Poisonous snakes, animals, plants
- Weather
- Heavy equipment
- Tools

Several factors distinguish the hazardous waste site environment from other occupational situations involving hazardous substances. One important factor is the uncontrolled condition of the site. Even extremely hazardous substances do not

Figure 2.1 Explosions, such as the one shown, are always a potential at hazardous waste sites.

Figure 2.2 A rattlesnake is shown at a site in Southern California. Always be on guard for snakes at waste sites.

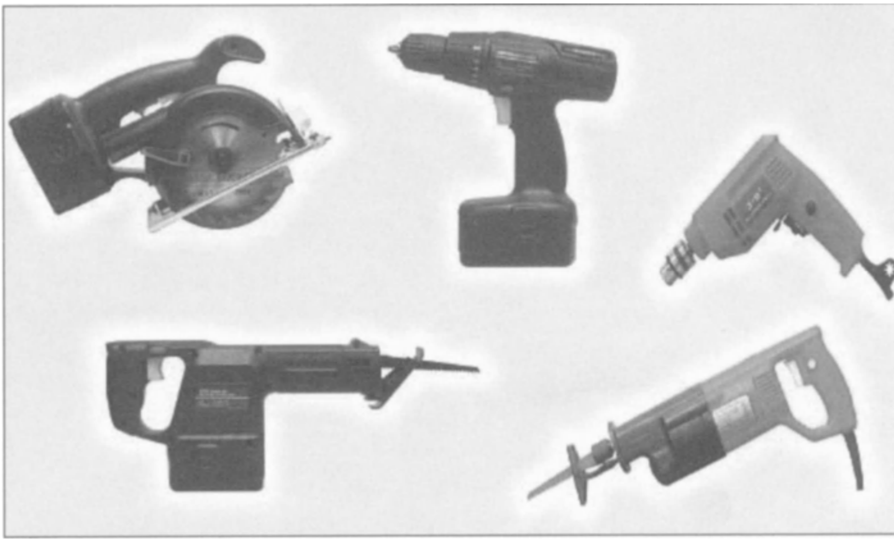


Figure 2.3 Power tools can be very helpful in performing many tasks. They can also be a hazard to workers, especially when not used properly or used by workers unfamiliar with their operation.

endanger human health or safety if they are handled properly. However, improper control of these substances can result in a serious risk to site workers, as well as the general public.

Another factor is the large variety and number of substances that may be present at a site. Any individual location may contain hundreds or even thousands of chemicals. Frequently, an accurate assessment of all chemical hazards is impossible due to the large number of substances and the potential interactions among the substances. In addition, the identity of all the substances on site is frequently unknown, particularly in the initial stages of a site investigation. The Project Team Leader (or similarly titled person in your organization) will often be required to select protective measures based on extremely limited or no information. Finally, workers are subject not only to the hazards of direct exposure, but also to dangers posed by the often disorderly physical environment of hazardous waste sites and the stress of working in protective clothing.

The combination of all these conditions results in a working environment that is characterized by numerous and varied hazards which:

- May pose an immediate danger to life or health (IDLH)
- May not be immediately obvious or identifiable
- May vary according to the location onsite and the task being performed
- May change as site activities progress

Figure 2.4 Workers are shown in chemical protective clothing.

General categories of hazards that may be present at a site are described in this chapter. In approaching a site, it is prudent to believe that all these hazards are present until site characterization (assessment) has proven otherwise. A site health and safety program, as described in a subsequent chapter of this book, must provide comprehensive protection against individual known hazards. The safety plan must be continuously modified with respect to new information and often changing site conditions.

Chemical Exposure

Preventing exposure to toxic chemicals is a primary concern at hazardous waste sites. Most sites contain a variety of chemical substances in gaseous, liquid, or solid form. These substances can enter the unprotected body by inhalation, skin absorption, ingestion, or through a puncture wound (injection). A contaminant can cause damage at the point of contact or can act systemically, causing a toxic effect at a part of the body distant from the point of initial contact.

Chemical exposures are generally divided into two categories: acute or chronic. Symptoms resulting from acute exposures usually occur during or shortly after exposure to a sufficiently high concentration of a contaminant. The concentration required to produce such effects varies widely from chemical to chemical. The term "chronic exposure" generally refers to exposures to "low" concentrations of a contaminant over a long period of time. The "low" concentrations required to produce symptoms of chronic exposure depend upon the chemical, the duration of each expo-

Figure 2.5 Two workers enter an IDLH area.

sure, and the number of exposures (as well as the individual involved). The symptoms of an "acute exposure" may be completely different from those resulting from chronic exposure.

For either chronic or acute exposure, the toxic effect may be temporary and reversible, or may be permanent (disability or death). Some chemicals may cause obvious symptoms such as burning, coughing, nausea, tearing eyes or rashes. Other chemicals may cause health damage without any such warning signs (this is a particular concern from chronic exposures to low concentrations). Health effects such as cancer or respiratory disease may not become manifested for several years or decades after exposure. In addition, some toxic chemicals may be colorless and/or odorless, may dull the sense of smell, or may not produce any immediate or obvious physiological sensations. Thus, a worker's senses or feelings cannot be relied upon in all cases to warn of potential exposure to hazardous substances.

The effects of exposure not only depend on the chemical, its concentration route of entry, and duration of exposure, but may also be influenced by personal factors such as the individual's smoking habits, alcohol consumption, medication use, nutrition, age and sex.

An important exposure route of concern at a hazardous waste site is inhalation. The lungs are extremely vulnerable to chemical agents. Even substances that do not directly affect the lungs may pass through lung tissue into the bloodstream, where they are transported to other vulnerable areas of the body. Some toxic chemicals present in the atmosphere may not be detected by human senses, i.e., they may be colorless, tasteless, odorless, and their toxic effects may not produce any immediate symptoms. Respiratory protection is, therefore, extremely important if there is a possibility that the work site atmosphere may contain such hazardous substances. Chemicals can also enter the respiratory tract through punctured eardrums. Where this is a hazard, individuals with punctured eardrums should be evaluated by a medical professional, specifically to determine if such a condition would place them at unacceptable risk and preclude their working at the task in question.

Direct contact of the skin and eyes by hazardous substances is another important route of exposure. Some chemicals directly injure the skin. Some pass through the skin into the bloodstream where they are transported to vulnerable organs. Skin absorption is enhanced by abrasions, cuts, heat, and moisture. The eye is particularly vulnerable because airborne chemicals can dissolve in its moist surface and be carried to the rest of the body through the bloodstream (capillaries are very close to the surface of the eye). Wearing protective equipment, not using contact lenses in contaminated atmospheres (since they may trap chemicals against the eye surface), keeping hands away from the face, and minimizing contact with the liquid and solid chemicals can help protect against skin and eye contact.

Although ingestion should be the least significant route of exposure at a site, it is important to be aware of how this type of exposure can occur. Deliberate ingestion of chemicals is unlikely; however, personal habits such as chewing gum or tobacco, drinking, eating, smoking cigarettes, and applying cosmetics (including sun block or lip balm) on site may provide a route of entry for hazardous chemicals.

Figure 2.6 Workers are shown eating in the clean zone.

The last primary route of chemical exposure is injection, whereby chemicals are introduced into the body through puncture wounds (for example, by stepping or tripping and falling onto contaminated sharp objects). Wearing safety shoes, avoiding physical hazards, and taking common sense precautions are important protective measures against injection.

Figure 2.7 Sturdy work shoes like the pair shown are often worn by workers at hazardous waste sites.

Explosion and Fire

The risk of fire and/or explosion is always present at a hazardous waste site. This is true because of the many tasks that may be required to be conducted. There are many potential causes of explosions and fires at hazardous waste sites:

- Chemical reactions that produce explosion, fire or heat
- Ignition or explosive or flammable chemicals
- Ignition of materials due to oxygen enrichment
- Agitation of shock-or-friction-sensitive compounds
- Sudden release of materials under pressure

Explosions and fires may arise spontaneously. However, more commonly, they result from site activities, such as moving drums, accidentally mixing incompatible chemicals, or introducing an ignition source (such as a spark from equipment) into an explosive or flammable environment. At hazardous waste sites, explosions and fires not only pose the obvious hazards of intense heat, open flame, smoke inhalation, and flying objects, but may also cause the release of toxic chemicals into the environment. Such releases can threaten both personnel on site and members of the general public living, working or traveling nearby. To protect against the hazards:

- Have qualified field personnel monitor for explosive atmospheres and flammable vapors.
- Keep all potential ignition sources away from an explosive or flammable environment.
- Use non-sparking, explosion-proof equipment.
- Follow safe practices when performing any task that might result in the agitation or release of chemicals.

Oxygen Deficiency

The oxygen content of normal air at sea level is approximately 21 percent by volume. Physiological effects of oxygen deficiency in humans are readily apparent when the oxygen concentration drops below 19.5 percent by volume. 19.5 % oxygen is also the minimum level required by OSHA to perform work without wearing a supplied air respirator. Oxygen concentrations lower than 16 percent by volume can result in nausea and vomiting, brain damage, unconsciousness, and death. To take into account individual physiological responses and errors in measurement, concentrations of 19.5 percent oxygen or lower are considered to be indicative of oxygen deficiency. Table 2.1 shows the oxygen levels and the effect on personnel.

Figure 2.8 This radiation meter is used to determine presence of radioactive materials at certain hazardous waste sites where they are suspected.

TABLE 2.1 Oxygen levels and the effect on personnel

Atmospheric Oxygen Concentration (%02)	Possible Results
19.5	Minimum requirements for worker protection.
8-10	Unconscious without warning and so rapidly that individuals cannot help or protect themselves.
6-8	Fatal in less than 6 minutes.
4-6	Coma in less than 40 seconds with subsequent death.

It should be noted that the table above only references oxygen-deficiency. Carbon dioxide, ammonia, and other gases may pose hazards at other concentrations regardless of the amount of oxygen available. In addition, oxygen-enriched atmospheres (greater than 23.5% Oxygen) may create fire and explosion hazards and should also be avoided.

Oxygen deficiency may result from the displacement of oxygen by another gas, or the consumption of oxygen a chemical reaction. Confined spaces or low-lying areas are particularly vulnerable to oxygen deficiency and should always be monitored prior to entry. Qualified field personnel should always monitor oxygen levels and must use atmosphere-supplying respiratory equipment when oxygen concentrations drop below 19.5% by volume.

Ionizing Radiation

Although not every hazardous waste site will pose a radiation hazard to workers, the potential is certainly there, especially when we consider medical waste sites, abandoned properties, and other sites on which radioactive material may have been used or disposed over the years.

Radioactive materials emit one or more of three types of harmful radiation: alpha, beta, and gamma. Alpha radiation has limited penetration ability and is usually stopped by clothing and the outer layers of the skin. Alpha radiation poses little threat outside the body, but can be hazardous if materials that emit alpha radiation are inhaled or ingested.

Beta radiation can cause harmful "beta burns" to the skin and damage the subsurface blood system. Beta radiation is also hazardous if materials that emit beta radiation are inhaled or ingested. Use of protective clothing, coupled with scrupulous personal hygiene and decontamination, affords good protection against alpha and beta radiation.

Gamma radiation easily passes through clothing and human tissue and can also cause serious permanent damage to the body. Chemical-protective clothing offers no protection against gamma radiation itself; however, use of respirator and other protective equipment can help keep radiation-emitting materials from entering the body by inhalation, ingestion, injection, or skin absorption.

If levels of radiation above natural background are discovered, consult a health physicist. At levels greater than 2 mrem/hr, all site activities should cease until the site has been assessed by a heath physicist.

Figure 2.9 A sign similar to this one may be seen at hazardous wastes involving radioactive materials.

BIOLOGICAL HAZARDS

Wastes from hospitals and research facilities may contain disease-causing organisms that could infect site personnel. Like chemical hazards, etiologic agents may be dispersed in the environment via water and wind. Other biologic hazards that may be present at a hazardous waste site include poisonous plants, insects, animals and indigenous pathogens. Protective clothing and respiratory equipment can help reduce the chanced of exposure. Thorough washing of any exposed body parts and equipment will help protected against infection.

Figure 2.10 This symbol is an indication that biohazards are present and proper precaution must be taken when working in the area.

General Safety Hazards

If you take away the chemical related hazards, then you are working at any construction site in the country. Work sites are loaded with safety hazards, each one having different issues that workers must encounter on a daily basis. Hazardous waste sites may contain numerous safety hazards such as the following:

- Holes, ditches, uneven or slippery terrain
- Precariously positioned objects, such as drums or boards that may fall
- Sharp objects, such as nails, metal shavings, and broken glass pieces
- Slippery surfaces and walkways
- Steep grades
- Excavations
- Unstable surfaces, such as walls that may cave in or flooring that may give way

Some safety hazards are a function of the work itself. For example, heavy equipment creates an additional hazard for workers in the vicinity of the operating equipment. Protective equipment can impair a worker's agility, hearing, and vision, which can result in an increased risk of an accident.

Accidents involving physical hazards can directly injure workers and can create additional hazards, for example, increased chemical exposure due to damaged pro-

Figure 2.11 Weather can add to the slippery surface problem, as shown in this picture of a site in Maryland. Mud was caused after several days of heavy rain. The result was people and equipment having difficulty moving.

Figure 2.12 This excavation contains petroleum hydrocarbon-contaminated soil which is being removed from a site in Minnesota.

tective equipment, or danger of explosion caused by the mixing of chemicals. Site personnel should constantly be on the lookout for potential safety hazards, and should immediately inform their supervisors or foremen of any new hazards so that corrective action can be taken to eliminate or reduce the hazard(s).

Electrical Hazards

Overhead power lines, downed electrical wires, and buried cables all pose a danger of shock or electrocution if workers contact or sever them during site operations. Electrical equipment used on site may also pose a hazard to workers. To help minimize hazard, low-voltage equipment with ground fault interrupters and watertight, corrosion-resistant connecting valves should be used on site. In additional, lighting is a hazard during outdoor operations, particularly for workers handling metal containers or equipment. To eliminate this hazard, weather conditions should be monitored and work should be suspended during electrical storms. An additional electrical hazard involves capacitors that may retain a charge. All such items should be properly grounded before handling. OSHA Standard 29 CFR Part 1910.137 describes the proper clothing and equipment for protection against electrical hazards.

Figure 2.13 Care and caution must be exercised when working on sites with overhead utilities such as the one pictured above.

Heat Stress

Heat stress is a major hazard, especially for workers wearing protective clothing. The same protective materials that shield the body from chemical exposure also limit the dissipation of body heat and moisture. Personal protective clothing can therefore create a hazardous condition. Depending on the ambient conditions and the work being performed, heat stress can occur very rapidly-within as little as fifteen minutes. It can pose as great a danger to worker health as chemical exposure. In its early stages, heat stress can cause rashes, cramps, discomfort and drowsiness, resulting in impaired functional ability that threatens the safety of both the individual and coworkers. Continued heat stress can lead to heat stroke and death. Avoiding overprotection, careful training and frequent monitoring of personnel who wear protective clothing, judicious scheduling of work and rest periods, and frequent replacement of fluids can protect against this hazard. Cool vests can help alleviate some of the heat, and are often worn by personnel in warmer climates.

Cold Exposure

Unfortunately, we cannot select the type of climate, the part of the country where we might work or the weather that we work in. Often times, we are required to work in conditions that are less than ideal and cold weather is one such condition. Cold injury (frostbite and hypothermia) and impaired ability to work are dangers at low temperatures and when the wind-chill factor is low. To guard against them, workers are urged to do the following:

- Wear appropriate clothing (Layers are suggested)
- Have warm shelter readily available
- Carefully schedule work and rest periods
- Monitor workers' physical conditions

Figure 2.14 When worn in warm climates, the cool vests provide relief to workers from heat related illness and injuries.

Noise

Noisy work environments are almost expected in the hazardous waste industry. So often we find ourselves at sites working with pumps, motors, heavy industrial equipment and the like. Work around large pieces of earth moving equipment frequently creates excessive noise. The effects of noise can include:

- Workers being startled, annoyed, or distracted
- Physical damage to the ear, pain, and temporary and/or permanent hearing loss
- Communication interference that may increase potential hazards due to the inability to warn of danger and the proper safety precautions to be taken

If employees are subjected to noise exceeding an 8-hour, time-weighted average sound level of 90 Dba (decibels on the A-weighted scale), feasible administrative or engineering controls must be utilized. In addition, whenever employee noise exposures equal or exceed an 8-hour, time-weighted average sound level of 85 Dba, employers must administer a continuing, effective hearing conservation program as described in OSHA regulation 29 CFR Part 1910.95.

Poisonous Snakes, Insects, and Plants

One of the hazards that many workers would rather do without is the exposure to snakes, insects and plants. Of course the location of the hazardous waste site will somewhat be the determining factor in whether or not workers are exposed to these hazards. Not all parts of the country have poisonous snakes, insects and plants.

The West Coast, for example, is noted for black widow and brown recluse spiders. The southeastern United States has a variety of poisonous snakes and scorpions (stinging hazard). Poison ivy, poison oak and poison sumac are hazards that many of us will face, as it is common throughout the lower forty-eight states. There is no poison ivy, oak or sumac in Alaska.

Figure 2.15 This worker, using a concrete cutting saw, is wearing hearing protection in the form of ear muffs to reduce the noise level.

Ticks are another hazard that workers in the Northeast have to be concerned with. Many workers at hazardous waste sites are exposed to deer ticks and then are diagnosed with Lyme disease, a fairly debilitating illness as a result of a bite from a tick.

While we never want to work with some of these hazards, workers find themselves face to face with rattlesnakes, poisonous spiders and a variety of poisonous plants. These need to be identified prior to sending people into the field, when possible. Insect repellent, spray for poison ivy, oak, sumac, and chaps or snake boots are all engineering controls that we might consider when dealing with these hazards.

Weather

We have already discussed the heat and cold environments that workers are required to work in and the hazards associated with each of them. Some jobs may also have workers operating in rain, fog, sleet, snow and lightning. Care and caution must always be taken when placing workers in any of these weather related situations. An inclement weather policy may be something that company officials want to consider writing, so as to deal with the hazards in advance.

Heavy Equipment

Many hazardous waste sites utilize heavy equipment to perform assignments that individuals with shovels and hand tools cannot perform. Heavy equipment, such as

Figure 2.16 Poison ivy plants can cause workers a great deal of aggravation if not recognized early and dealt with properly. Be on the lookout for poison oak and sumac as well.

Figure 2.17 Ticks are very common pests in many parts of the country. They can cause serious illness if you are bitten. Perform a tick check at various times during the day.

Figure 2.18 These snakes were found at a site. Can you imagine showing up to work and finding this?

Figure 2.19 Lightning is a real danger to workers, particular in open areas, such as the picture indicates. Workers should seek shelter immediately.

Figure 2.20 Often times, workers have to plow their way to the job site!

Figure 2.21 This shows heavy equipment in use at a job site.

bulldozers, excavators, front end loaders, bobcats, forklifts, and similar machinery are useful tools, but operators and workers must be mindful that they are not the only ones on the site. Equipment often has blind spots and operators are unable to see workers or trespassers on a site. Workers operating in the vicinity of heavy equipment must also be careful to observe safe footing, and know the whereabouts of the equipment at all times. Never leave a cooler or lunchbox on the side of the machine. Remember that the equipment is continuously moving and is not your personal storage space!

Reflective vests should be worn by all site personnel, especially when heavy equipment is being operated. Equipment, as previously discussed, can also be noisy and hearing protection may be required to be worn.

Tools

The power and hand tools we rely on to make our jobs easier can also contribute to many accidents and injuries at our work sites. Some of the hazards associated with tools include:

- Electrical Hazard
- Lack of Ground Fault Circuit Interrupter (GFCI) when used outdoors
- Noise from power tools
- Vibration injuries from jackhammers and similar tools
- Misuse of tools (using a screwdriver for a pry bar instead of its intended use)

Figure 2.22 This worker, wearing a reflective vest, is in the proper attire for working at many sites. Reflective clothing allows workers to be seen by equipment operators.

Figure 2.23 This worker is using a jackhammer to remove contaminated concrete. Notice the protective equipment he is wearing.

I am not saying that we shouldn't use power tools to do the job, on the contrary. Power tools are extremely efficient and useful. Workers must always be diligent to follow company policies regarding proper and safe tool use. Tools that are broken or out of service should be tagged, so as to avoid any safety issue arising from use of that piece of equipment.

DEFINITION OF HAZARDOUS MATERIALS VS. HAZARDOUS WASTE

While there are many agencies involved with hazardous materials, each one of those agencies has their own unique definition, based on the focus of the regulatory agency. It is not necessarily important to memorize a book definition of a hazardous material, but it is very important to know what a hazardous material (an example) is and then identify (by example) a hazardous waste.

Generally speaking, a hazardous material is a naturally occurring or manmade material that because of its physical or chemical properties can cause the deterioration of other materials or can be injurious to living things. It's worthy of note that we cannot function in our daily lives without hazardous materials. Some examples of hazardous materials include:

- Paint
- Gasoline
- Cleaning products

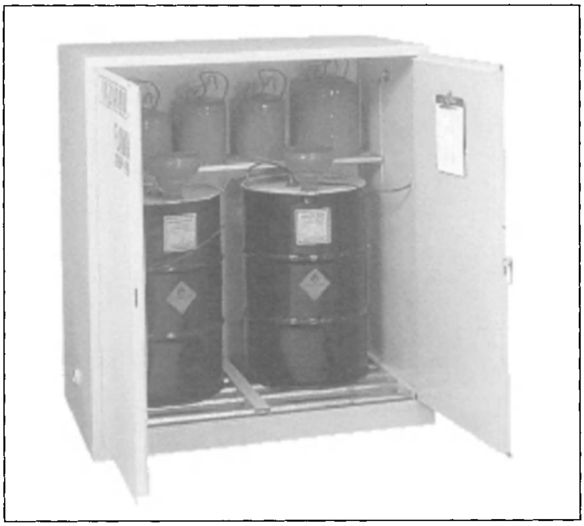


Figure 2.24 Hazardous materials are properly stored in the above cabinet

- Oil
- Turpentine
- Mineral spirits
- Can you think of some others that you might have at home or at work?

Hazardous materials and hazardous waste is not the same thing! Many people use the terms interchangeably and they are incorrect in doing so. A hazardous material becomes a hazardous waste when:

- It is not used properly.
- It is not stored properly.
- It is not transported properly.
- It is spent (used up).

Some examples of hazardous waste include the following:

- Used oil
- Gasoline that has been spilled
- Paint that has been used up

Figure 2.25 Hazardous waste is shown in a puddle.

Hopefully the differences are now clear between hazardous materials and hazardous waste. One we use daily (hazardous materials) and the other (hazardous waste) is really a byproduct. Proper terminology is important when describing materials and waste.

CLASSIFICATION OF HAZARDOUS MATERIALS

Hazardous materials can be described by some regulatory agencies as hazardous in four ways:

- Flammable or Explosive
- Corrosive
- Reactive
- Toxic or Poisonous

Materials that are hazardous because they are radioactive are under the jurisdiction of the Department of Energy or the Nuclear Regulatory Commission depending on the circumstances.

Physical Properties of Hazardous Materials

The state of a material (gas, liquid, or solid) strongly influences the potential danger posed by that material. Although it seems hard to believe, a material that is dangerous in one state may be relatively innocuous in another. Gases are more hazardous than liquids or solids, as a general rule of thumb. Some other pertinent information:

Figure 2.26 The seal of the Nuclear Regulatory Commission is shown here.

- Flammable gases ignite easily.
- Toxic gases can easily enter the body through inhalation.
- Gases in the environment are more difficult to contain and control than liquids or solids, but they are more easily dispersed.
- Liquids are more hazardous than solids.
- Liquids generally have a higher vapor pressure than solids and flammable liquids ignite easily only when vaporized.
- Vapors from toxic liquids can be inhaled.
- Liquids have the greatest potential for skin absorption compared to gases or solids. Toxic liquids can be absorbed by the skin if spilled or splashed.
- Hot or cold liquids have a greater risk of thermal injury than gases or solids. Liquids can be very hot, such as liquid sulfur (246 F) or very cold, such as liquid nitrogen (-230 F).
- Liquids can sink, float or dissolve in water. In the environment, they can be collected, contained or absorbed if insoluble; they can be dispersed or diluted if soluble.
- Solids are generally less hazardous than gases or liquids unless finely divided, such as a powder.
- Flammable solids will burn when the ignition temperature is reached.
- Toxic solids have the most difficulty gaining access to the body.
- Solids in the environment can be easily collected and contained.

Vapor Density and Specific Gravity

The vapor density and the specific gravity are important pieces of information when dealing with environmental pollutants. These properties affect the way the material travels through the environment, the kinds of hazards that it poses, and the safety precautions that must be taken to obtain protection against the harmful effects of the material. These properties are listed in: The *Merck Index; The Condensed Chemical*

Dictionary; The CRC Handbook of Chemistry and Physics, and other similar technical reference texts.

Vapor densities of a material are given for the pure material and generally do not apply to parts per million (ppm) concentrations of the material. At ppm concentrations, the contaminated air has essentially the same density as uncontaminated air at the same temperature and pressure.

If the vapor density is less than one, the material is lighter than air and will rise and dissipate in the air if unconfined. The material could collect in high spots such as ceilings if confined. One example of a gas lighter than air is hydrogen.

If the vapor density is greater than one, the material is heavier than air and will sink. The material will linger near the ground and collect in low spots. Examples are carbon dioxide (can displace air), chlorine (toxic), gasoline vapors (explosive), and trichloroethylene (can displace air).

If the specific gravity is less than one, the material is lighter than water and will float on water.

If the material enters the environment, it may sink through porous materials such as sand and soil until it encounters a water layer (i.e., a ground-water aquifer), where it will float. If the specific gravity is greater than one, the material is heavier than water and will, therefore, sink. This is true of materials such as carbon disulfide, virtually all chlorinated solvents, and polychlorinated biphenyls (PCBs).

If the material enters the environment, it will sink in porous materials such as soil or sand, and then sink, unaffected by water, until it reaches a nonporous surface.

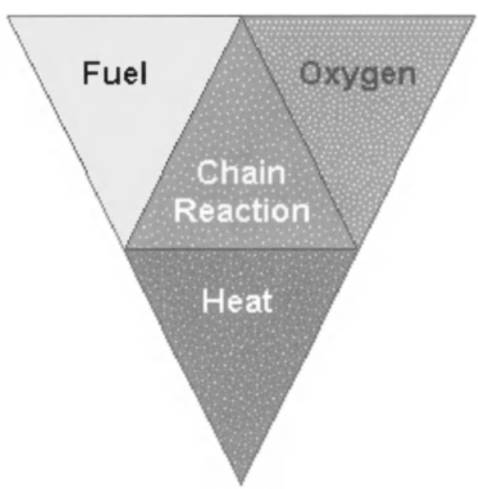


Figure 2.27 Fire pyramid shows the components needed for fire.

Flammability

In order for a fire to occur, fuel, oxygen and heat must be brought together. If any one is missing, combustion cannot take place. The factors are designated the "fire triangle." Recent studies in fire chemistry have expanded the theory of fire to include chemical chain reactions involving free radicals as a necessary element in fire. Thus, there is now the "fire pyramid".

"The Fire Pyramid," oxygen, heat fuel, and chain reactions are necessary components of a fire. If you speed up the process an explosion is the result.

There are several ways to control or extinguish a fire. To extinguish a fire by cooling, it is only necessary to remove a small portion of the heat. Another way to extinguish a fire is by removing the fuel. The fire will be quickly extinguished if the fuel can be removed, such as by shutting off the gas or closing the valve on a line feeding some flammable liquid to a fire. Fires can also be smothered by excluding air, such as placing a lid over fuel burning in a container, or by covering with soil, sand or other material. Additionally, the fire will stop burning if the chain reaction is interrupted. Many extinguish agents scavenge the free radicals and ions formed in the flame and interrupt the combustion process, such as the halon extinguish agents.

Explosive Limits

Flammable gases and vapors of flammable liquids will ignite in air when exposed to a source of ignition. However, each substance has a concentration above and below which it will not burn. The minimum concentration below which a flammable gas or vapor from a liquid will not burn, even when exposed to an ignition source is called the lower explosive limit (LEL). The number determined for the lower explosive limit is a function of the apparatus to make the test and therefore, different numbers for the LEL may appear in different reference texts. The maximum concentration above which a substance will not burn is called the upper explosive limit (UEL). In some places this is called the upper flammability limit (UFL). Continuous monitoring with a LEL instrument is essential in an environment of flammable gases or liquid vapors.

Flash Point

Flammable liquids do not burn as a liquid, but must vaporize to create a combustible combination of vapors and air. A material may not give off enough vapors at ambient temperature to ignite, but will if heated sufficiently. The minimum temperature that a material gives off vapors in sufficient quantity to produce a combustible mixture over the surface of the liquid is called the flash point.

Figure 2.28
Flammable Liquid placard

Liquids are divided into extremely flammable, combustible, and non-combustible on the basis of their flash points. The United States Department of Transportation (DOT) considers liquids with a flash point of less than 80 F to be flammable and requires shipments of such materials to be placarded as flammable. Liquids having a flash point between 80 F and 200 F are considered combustible by the DOT and must be placarded as such.

Other regulatory agencies and standard setting organizations may use different flash points to classify flammable and combustible liquids.

Flammable Solids

A flammable solid is one that will ignite through friction or spontaneous chemical reaction with moisture in the air. The temperature at which a solid begins to burn is called the ignition or kindling temperature.

While phosphorus is an example of the flammable solid which as an ignition temperature of 86 F (such as on the surface of the body) and exposed to air. White phosphorous will ignite and continue to burn.

Figure 2.29
Flammable Solid placard

Firefighting and Fire Prevention

Firefighting and fire prevention are important considerations in dealing with hazardous materials. The use of improper methods to extinguish a fire could increase the potential fire hazards and the risk of harm greatly. In order to deal with fires more effectively, the National Fire Protection Association (NFPA) has classified fires by the type of fuel and contributing hazards in the following ways.

Class A—Wood, Paper, and Cloth—Symbol: A
Water is the extinguishment of choice for Class A fires because it not only interferes with the chemical chain reaction and extinguishes the fire; it cools the fuel and remains with the fuel to keep the fire from rekindling. Certain dry chemical extinguishers are also approved for Class A fires.

Class B—Flammable Liquids—Symbol: B
The fires in the vapor-air mixture over the surface of flammable liquids such as gasoline, oil, grease, paints and thinners cannot be extinguished by a solid stream of water. The water is likely to spread the liquid and make the fire worse. Water will sink to the bottom of the flammable liquid and be totally ineffective at extinguishing the blaze. Carbon dioxide and dry chemical extinguishment are the recommended extinguishing agents for Class B fires.

Class C—Fires Involving Energized Electrical Equipment—Symbol: C
Water and other electrically conductive extinguishing agents cannot be used on electrical fires because of the electrical shock hazard and because they may make the fire

situation worse. Carbon dioxide, halon and dry chemical extinguishers are recommended for all Class C type fires.

Class D—Fires Involving Flammable Metals—Symbol: D
Water cannot be used to extinguish a fire involving a burning metal (magnesium, titanium, etc). Although each flammable metal presents a unique case, water generally will react chemically with the metal and make the fire situation worse. Each type of flammable metal has a particular type of extinguishing agent recommended which should not be used for other type of flammable metals. Carbon dioxide, B/C, and A/B/C dry chemical extinguishers are generally ineffective on combustible metal fires and may react chemically with the burning metal to make the fire situation much worse.

Portable Fire Extinguishers

The four basic types of portable fire extinguishers in use today are:

- Pressurized Water
- Carbon Dioxide
- Dry Chemical
- Halon

Pressurized Water
The pressurized water extinguisher is for Class A fires only and is a 2½ or 5 gallon tank of water with compressed air normally at 100 psi in the head space above the water to force the water out of the extinguisher when the valve is opened. The stream of water should be directed at the base of the flames from about 5 to 6 feet away.

Carbon Dioxide
The carbon dioxide extinguisher is for Class B and C fires only, and employs a directed stream of carbon dioxide which quenches the flame with its cold temperature and displacement of oxygen. It has the advantage of not leaving a residue. However, the lack of a residue prevents the carbon dioxide extinguisher from exerting a

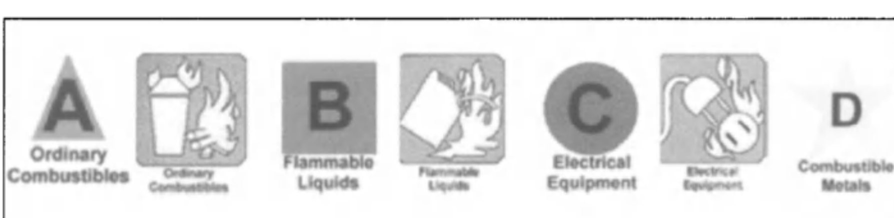


Figure 2.30 The four classes of fire and their universal symbols.

Figure 2.31 Three types of fire extinguishers

long lasting effect on hot embers, and the fire may rekindle when the carbon dioxide has dissipated.

Dry Chemical

Several formulations of dry chemical fire extinguishers are available, some with Class B/C rating and some with Class A/B/C rating. The dry chemical extinguishing agents interfere with the chain reaction of the fire and, to some extent, smother the fire. These agents do leave a residue which is often messy and harmful to electrical or computer components. However, the residue provides continuing action and prevention of re-ignition.

Halon

Portable halon fire extinguishers have the advantage of providing a fast knockdown and leaving no residue. However, they are very expensive, do not provide as much extinguishing capability as a similarly sized extinguisher of any of the types listed above, and may generate very toxic by-products if used on a well-developed fire or a very hot fire.

Some combustible materials may undergo autocombustion in the presence of strong oxidizers, but more commonly, if the heat released by the slow oxidation process that goes on at room temperature for the material. Examples of this are seen in piles of oil rags, coal mounds, and animal dung heaps.

Toxic Products of Combustion

When materials burn, the products of combustion are often toxic. Some materials produce much more significant amounts of hazardous combustion products then are ordinarily encountered. Some examples are:

- Carbon monoxide from incomplete combustion
- Hydrogen chloride and phosgene from PVC plastics and chlorinated solvents
- Hydrogen cyanide from acrylic plastic, polyurethane, wool, and natural rubber
- Hydrogen fluoride
- Sulfur dioxide from vulcanized rubber

Corrosives

A corrosive material is one that has the ability to cause deterioration or alteration of metal surfaces. Visible destruction or alteration of skin tissue at point of contact is also a factor. Corrosive materials include acids, alkalis, materials that form acids or alkalis when combined with water, and elemental halogens.

Acids

Acids undergo certain common reactions:

- Acids react with metals more chemically reactive than hydrogen to form a salt and release hydrogen gas. Hydrogen gas is flammable.
- Zinc metal and hydrochloric acid react to form zinc chloride and hydrogen gas.
- Iron metal and sulfuric acid react to form ferric sulfate and hydrogen gas.
- Acids react with metal oxides and metal hydroxides to form salts and water.
- Iron oxide (rust) reacts with hydrochloric acid (rust remover) to form soluble ferric chloride and water.
- Sodium hydroxide reacts with hydrochloric acid to form salt and water, neutralizing the acid and hydroxide.
- Acids react with carbonates to form salts, water and release carbon dioxide gas. This reaction represents a method for neutralizing and acid spill.
- Sodium carbonate reacts with hydrochloric acid to form sodium chloride, water and carbon dioxide gas.

Most people respect an acid's ability to produce burns, some of which can be severe and result in permanent injury. However, some acids can be dangerous even if they do not come into direct contact with skin. Sulfuric acid is an example of this and it:

- Has vigorous affinity for water.
- Reacts violently with chlorates, perchlorates, and permanganates.
- Has an exceptionally high boiling point.
- Is a strong oxidizing acid.

Alkalis

Alkalis, although chemically the opposite of acids, produce strikingly similar results when they come into contact with skin. Alkalis have the following characteristics:

- Alkalis react with acids to produce salt and water.
- Sodium hydroxide reacts with sulfuric acid to form sodium sulfate and water.
- Alkalis react with metals to form salt and hydrogen.
- Potassium hydroxide reacts with aluminum and water to form aluminum hydroxide and hydrogen gas.
- Alkalis react with metal salts to form metal hydroxides
- Calcium hydroxide reacts with copper chloride to form calcium chloride and copper hydroxide.

Reactivity of Some Common Elements

Many common elements will react quite violently with other chemicals or when exposed to certain physical conditions. Increasing the atmospheric concentration of oxygen has the following results: decreases the flash point; decreases the lower explosive limit; raises the upper explosive limit; and decreases the minimum ignition energy.

As a liquid, it is cryogenic and can actually freeze living tissue to the point where the tissue will shatter! As a cryogenic liquid it will combine with hydrocarbons to form a shock sensitive explosive. Extreme caution must always be used when encountering shock sensitive materials.

Water-Reactive Materials

Some materials can react chemically or physically with water. Water can combine with burning metals to create a fire of greater magnitude. Water, even simple moisture from the air, can cause some metals and other substances to ignite. Substances that spontaneously ignite are called "pyrophoric". Some metals that are pyrophoric if finely divided include the following:

- Magnesium
- Titanium
- Thorium

- Uranium
- Plutonium

Some of these materials are actually encountered at hazardous waste sites. Remember that many years ago, materials were often dumped and buried, and the consequences are being discovered now.

The most serious hazard is encountered when water participates in a chemical reaction. This reaction is called "hydrolysis". Hydrolysis products can be corrosive, toxic and/or flammable.

A variety of chemicals can react with water to produce toxic products or unstable compounds. Some of these include:

- Acetyl bromide
- Phosophorous pentoxide
- Phosphorous pentasulfide
- Chlorosulfonic acid
- Acetic anhydride

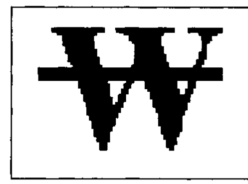


Figure 2.32 This symbol indicates that the material is water reactive.

Oxidizing Materials

Oxidizing materials can cause ignition, combustion, or detonation of organic materials, powered metals, and other reducing agents (oxidizable materials). Oxidizing agents are used as chlorinating and bleaching agents, fertilizers, pyrotechnic mixtures, and rocket propellants. Some common oxidizing agents are chlorates, perchlorates, and permanganates, to name a few.

Boiling Liquid Expanding Vapor Explosion (BLEVE)

A BLEVE occurs when a container of liquid ruptures and the temperature of the liquid are above its boiling point. As the pressure is released, the liquid changes to the vapor state, expanding in volume and releasing a tremendous amount of energy. Essentially, a BLEVE is container failure. The container becomes heated; pressure builds up and eventually the container fails (BLEVE).

Although not a common occurrence at hazardous waste sites, the potential is certainly there for a BLEVE to happen. A BLEVE is a physical process not dependent on the chemical properties of the materials involved. However, BLEVEs involving flammable or toxic material are far more serious because of the additional hazards involved.

A BLEVE can occur whenever a mobile or stationary closed container of liquid is exposed to fire or heat such that the temperature of the liquid in the vessel is raised above the boiling point at atmospheric pressure. BLEVEs are more likely to occur when the container has been overfilled so that the ullage is reduced or when the container has been damaged as in a fire or other accident.

BLEVEs have occurred as a result of accidents involving railroad tank cars, fixed, tanks, and over-the-road tank trucks. BLEVEs have involved both flammable and non-flammable liquids and gases. More BLEVE shave occurred during transportation accidents and emptying and filing operations, often delayed from the triggering event.

Some rules to consider enforcing when dealing with the potential of fire and explosions include:

- Extinguish all fires and smoking materials in the vicinity. When the use of lights is necessary, use only permissible electric flashlights. Keep internal combustion engines out of any possible vapor cloud. Use an air monitoring device to determine the boundary of the lower explosive limit (LEL) of a flammable vapor cloud.
- Keep all unauthorized persons away. That means ALL unnecessary people.
- If possible, dig holes or trenches or build earthen dikes in the path of flowing liquid to reduce the area of liquid surface from which vapors can be given off. The vapor of flammable gases is usually heavier than air and tends to form a layer on the ground. These vapors will flow following the slope of the ground and will settle in low places sheltered from the wind.

Figure 2.33 A Boiling Liquid Expanding Vapor Explosion or BLEVE is a container failure. This picture shows a tank which has suffered a BLEVE.

- Vapors may travel a considerable distance with the wind. In addition, vapors may spread in the upwind and crosswind directions. Dispersion will be aided by using streams of water to break up vapor streams at the point of leakage from the car. Water fog will tend to disperse vapors in still air.
- Do not permit flammable gas to drain into sewers since vapors arising from it may ignite at some point far from the leak, causing serious life and properly damage. Do not permit liquid to drain into water sources thus contamination may cause environmental harm.
- Locate all leaks and stop them if possible.
- Wrecking operations or transfer of contents of tanks of flammable gas should not be attempted until all vapors in that vicinity are dispersed. Cutting torches must not be used on either empty or loaded tanks, under any circumstances.
- If leaks are expected in handling, transfer the contents to another tank. The transfer of flammable gas tanks involved in accidents should not be undertaken by novices. Only authorized and trained hazardous material technicians should be allowed to perform these duties. Contact the shipper, consignee, or an experienced contractor for any transfer of the contents if your staff is not able or trained to handle it.

Flammable and Combustible Liquid

When tanks of flammable liquids are leaking, a fire may occur if they contain liquids with a flash point below 100°F (38°C). The flash point of a liquid is the lowest temperature at which the vapor given off by the liquid will mix with the air above the surface of the liquid to form an ignitable mixture. It is not the liquid that burns, but the vapor. The possibility of ignition is greatest for liquids having low flash points. The lower the flash point, the greater the probability is that the temperature will be materially higher than the flash point of the liquid. The higher the temperature, the greater the amount of vapor formed and the greater the hazard. Quite frequently, when leakage occurs in an accident, ignition is caused instantly by friction sparks.

Combustible liquids have flash points between 100°F and 200 F (38°C and 93°C). They are more difficult to set afire than flammable liquids, but once ignited, burn very well! On very hot days, low-flash-point combustible liquids may involve enough vapors to require handling as a flammable liquid, but combustible liquids generally do not involve sufficient vapor to support combustion.

If fire occurs, immediately:

- Rescue injured persons, if trained to do so, and you can do it safely.
- Pull away any other vehicles that are movable and not burning, if possible.
- Dig holes or build earthen dikes in the path of the burning liquid to limit the fire area and thereby protect adjacent property against fire damage.
- Control fire or protect property, but do not extinguish it until all spilled materials have burned. If exposures require the fire to be controlled, consider the use

of foam to reduce the intensity. An extinguished fire will create a flammable vapor hazard. Water streams are likely to float the liquid and spread the fire.

- Watch all tanks in the fire for evidence of bulging or the appearance of red "hot" spots in the metal, which are an indication that the strength of the steel at such spots is being reduced by heat to a point where it cannot hold the pressure maintained in the tank. The hot spots are caused by a flame playing against the shell of a tank care. Keep all persons away, because if the metal fails, a stream of burning liquid or vapor may be projected many feet.

Water steam supplied at the point of the flame impingement will prevent development of hot spots if sufficient water can be applied. If water streams are used to cool the tanks while hazardous materials are in the area, runoff should be controlled to limit environmental damage.

Do not puncture or rupture the shell of a tank involved in a fire. A puncture or rupture will increase the seriousness of the situation since any opening made in a tank will liberate more flammable liquid and extend the fire. The safety valves on the tanks are designed to limit internal pressure to must less than the designed bursting pressure of the tank, provided the valves are not buried or so obstructed that they cannot open. When a tank is in a position so that safety valves are buried, if it is safe to do so, an effort should be made to roll it into a position where the valves are able to function properly.

When vapors are burning at the safety valves, do not extinguish the flames. The leakage from the valves may spread over a large area and ignite. This may cause a sudden violent flash fire that may do great damage. It is safer to let the vapor burn at the valves or point of leakage.

If a fire does not occur immediately in an accident, the hazard of a leak of flammable liquid is greater than when the fire occurs immediately. The vapor given off by a flammable liquid will spread over a large area and will travel faster, especially with the wind, and then the liquid will flow. Vapors cannot be confined, they will ignite upon contact with any spark or flame, and will flash back to the liquid surface from which the vapor originated. After such a flash of fire the vapor burns above the surface of the liquid.

Guard against the hazards that exist as long as leakage is not on fire. These are a few tips to follow:

- Extinguish all fires and smoking materials in the vicinity. When lights are necessary, use only permissible electric flashlights.
- Keep internal combustion engines out of the flammable vapor area. Use an air monitoring device to determine the boundary of the lower explosive limit (LEL) of the flammable vapors.
- Keep all unauthorized persons out of the area.
- Dig holes or trenches or build earthen dikes in the path of flowing liquid surfaces from which vapors can be given off.

- Cover the liquid with sand, dirt, or foam to blanket the surface and reduce the rate of evaporation. The vapor of most flammable liquids is heavier than air and forms a layer along the ground which mixes slowly with the air. The mixing with air is increased by wind. The vapor flows along the ground following the slope of the ground and settles in two places sheltered from the wind. It will not drift or flow against the wind but may travel a considerable distance with the wind. Vapors can be dispersed by spraying with water as a fog.
- Do not permit liquid to drain into sewers since vapors arising from it may become ignited at some point far from the leak, causing serious damage to life and property. Do not permit liquid to drain into water sources.
- Locate all leaks and stop them if possible. Nonmetallic plugs are useful for this purpose.
- Wrecking operations or transfer of contents of tanks of flammable liquids should not be attempted until all vapors are dispersed. Cutting torches must not be used on tanks either empty or loaded. Many liquids regarded as safe under ordinary conditions are transported as combustible or non-regulated materials should be treated as dangerous in an accident scenario.
- An empty or partially empty tank with or without placards is very likely to contain a vapor-air mixture that may ignite. Fumes in any empty tank should be checked before cleaning for residual vapors.
- Move the least damaged vehicles to safety. Avoid sudden shocks or jars that might produce sparks or friction. No unnecessary attempt should be made to move a damaged tank from which flammable liquid is leaking.
- As a last resort, a tank may be moved by dragging, preferably using combustible gas detector measurements as a guideline. When leaks are expected in handling, empty the tank first by transfer of contents and make inert with nitrogen or another noncombustible gas.

SUMMARY

The ability to recognize and identify hazards is extremely important to the success of any operation involving hazardous materials. In the event that the exact identity of the material is not known, it's essential that personnel have the skills and knowledge to at least classify the material into a hazard class. The Department of Transportation identifies nine classes of hazardous materials. These are:

- Explosives
- Flammable, Non-Flammable and Poison Gases
- Flammable and Combustible Liquids
- Flammable Solids
- Oxidizers and Organic Peroxides

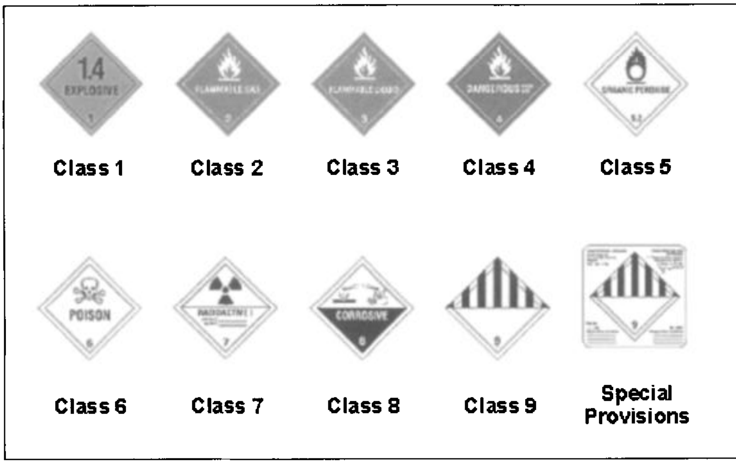


Figure 2.34 The above picture shows the nine Department of Transportation Hazard Classes.

- Poisonous and Infectious Substances
- Radioactive Materials
- Corrosives
- Other Regulated Materials (ORMs) or Miscellaneous Hazardous Materials

There are so many hazards and hazardous conditions that are part of the daily operations at hazardous waste sites, that it would be impossible to list all of them. Use your training and your fellow workers to help determine the hazards you will encounter and how to deal with them in a safe manner.

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE MANUAL
by Brian J. Gallant

3

SITE SAFETY PLAN

The purpose of the site safety plan is to establish requirements for protecting the health and safety of workers during all activities conducted at hazardous waste sites. It contains safety information, instructions, and procedures, and basically is a document that tells us "how we will do business at this type of site."

A site safety plan must be prepared and reviewed by qualified personnel for each hazardous substance response. Before operations at an incident commence, safety requirements must be written, conspicuously posted or distributed to all personnel, and discussed with them to ensure that everyone understands the hazards and risks associated with the project. The safety plan must be periodically reviewed to keep it current and technically correct. It will likely be one of the most scrutinized texts involved with any site.

Figure 3.1 The Site Safety plan is an integral component of your company's Safety and Health Program.

In non-emergency situations, for example, long-term remedial action at abandoned hazardous waste sites, safety plans are developed simultaneously with the general work plan. Workers can become familiar with the plan long before site activities begin. Emergency response generally requires verbal safety instructions and reliance on existing standard operating procedures until, when time permits, a plan can be written and put into operation.

The plan must contain safety requirements for routine (but hazardous) response activities and for unexpected site emergencies. The major distinction between routine and emergency site safety planning is the ability to predict, monitor, and evaluate routine activities. A site emergency is unpredictable and may occur anytime.

THE PLAN

At a minimum the site safety plan must:

- Describe the known hazards and evaluate the risks associated with the incident and with each activity conducted.
- List key personnel and alternates responsible for site safety, response operations, and for protection of public.
- Describe the Levels of Protection to be worn by personnel.
- Mark out specific work areas.
- Establish procedures to control site access.
- Describe decontamination procedures for personnel and equipment.
- Establish site emergency procedures. (What ifs?)
- Address emergency medical care for any injuries and toxicology problems.
- Describe requirements for an environmental surveillance program.
- Specify any routine and special training required for personnel.
- Establish procedures for protecting workers from weather-related issues.

The safety plan's scope, detail and length are based on the information available about the incident, the time available to prepare a site-specific plan, and the reason for responding to the situation. Each of these factors plays an important part in determining the features that will be outlined in the safety plan.

Site safety plans do not have to pass what I call the "weight test." In other words, it is not the size of the document or how many pages it contains, that is important. It's the contents of the plan that will make for a safe working environment. Many companies (or safety officials) that I have worked with copy someone else's plan because it contained some "good stuff." There is nothing wrong with using good material in your safety plan, however, the most important part of any written program or plan is the fact that YOU MUST BE DOING WHAT YOU SAY IN THE PLAN! Just because it looks good, or the plan is a thick document, doesn't mean it is any good. Cover what you need to in the plan, but carry out the activities that you put in your plan. The regulatory agencies will hold you responsible for the information you commit to in the safety plan.

Three general categories of response exist—*emergencies*, *characterizations* and *remedial actions*. Although considerations for personnel safety are generic and independent of the response category in scope, detail, and length, safety requirements and plans vary considerably. (Remember that each site or each response will be different, therefore, requiring unique plans.) These variations are generally due to the reason for responding, information available, and the severity of the incident with its potential danger to the worker.

EMERGENCIES

Emergencies generally require immediate action to prevent or reduce adverse effects. We always have the possibility of immediate hazards due to fire, explosion, and release of toxic vapors or gases; and they are of prime concern. Emergencies can vary greatly in respect to types and quantities of material involved, numbers or responders/workers, type of work to be accomplished, surrounding population affected, and other factors. Some emergencies last from a few hours to a few days.

- Information available: Varies from none to much. Usually information about the chemicals involved and their associated hazards are quickly obtained in transportation-related incidents or incidents involving fixed facilities. Determining the substances involved in some incidents such as mysterious spills, requires considerable time, effort and money.
- Time availability: Little time, requires rapid action to bring the incident under control.
- Reason for response: To implement prompt and immediate actions to control or mitigate dangerous or potentially dangerous situations.

In emergencies, time is usually not available to write lengthy and detailed safety plans. Decisions for responder safety are based on a continuous evaluation of ever changing conditions. Responding organizations must rely on their existing written standard operating safety procedures (SOPs) or a generic safety plan (as guidance), and verbal safety instructions modified to meet site specific conditions. Since heavy reliance is often placed on verbal safety instructions, an effective system to keep all responders informed must be established. Whenever possible, these incident-specific instructions should be written.

INCIDENT CHARACTERIZATION

In non-emergency responses, for example, preliminary inspections at hazardous waste sites or more extensive waste site investigations, the objective is to identify and characterize the chemicals and hazards involved, determine the extent of contamination, and recognize any risks to the neighboring population and the environment. Generally, initial inspections, detailed investigations, and extent of contaminations surveys are limited in the activities that are required and numbers of people involved. Initial or preliminary inspections typically require one or two days. Complete investigations may last over a much longer time period.

- Information available: Much background information is available from a variety of sources. There normally is limited on-site data for initial inspection.

On-site information is more fully developed through additional site visits and investigations.
- Time available: In most cases, adequate time is available to develop a comprehensive written site-specific safety plan.
- Reason for response: To gather data to verify or refute existing information, to gather information to determine scope of subsequent investigations, or to collect data for planning the remedial (corrective) action.

Under these circumstances, sufficient time is available to write safety plans. In scope and detail, plans tend to be brief, containing safety requirements for specific on-site work relevant to collecting data. As information is developed through additional investigations, the safety plan is modified and if necessary, more detailed and specific requirements are added.

REMEDIAL ACTIONS

Remedial actions are cleanup efforts that last over a long period of time. They start after more immediate problems at an emergency have been controlled, or they involve the mitigation of hazards and restoration of abandoned hazardous waste sites. A number of activities are required involving many people, a logistics and support base, extensive (and often, expensive) equipment, and more involved work activities. Remedial actions may require months to several years to completely accomplish the goals:

- Information available: Much is known about on-site hazards, from a variety of sources.
- Time available: There is ample time for work planning to take place.
- Reason for response: Systematic and complete control, cleanup, and site restoration efforts.

Since ample time is almost always available before work commences, the site safety plan tends to be more comprehensive and detailed. From prior investigations many details tend to be known about the hazardous materials or other hazards at the site, as well as the extent of contamination.

SAFETY PLAN DEVELOPMENT

To develop the plan, as much background information as possible should be obtained, time permitting, about the incident. This would include, but not be limited to:

- Incident Name, Location and Objectives
- Site Description

- Chemicals and Quantities Involved
- Hazards Associated with Each Chemical
- Behavior and Dispersion of Material Involved
- Types of Containers, Storage, or Transportation Methods
- Physical Hazards (be inclusive of all potential hazards)
- Prevailing Weather Condition and Forecast
- Surrounding Populations and Land Use
- Environmentally Sensitive Areas (ESA)
- Facility Records
- Preliminary Assessment Reports
- Off-site Surveys
- Topographic and Hydrologic Information

This information, initially available or obtained through subsequent characterization, provides a basis for developing a site-specific safety plan. Information is needed about the chemicals and hazards involved; the movement of material on and off the site, and potential contact with responders or the general public. This type of information is then used, along with the reason for responding (and work plan), to develop the safety plan. The plan is then customized to the conditions imposed by the incident and to its environmental setting. As additional information becomes available, the safety plan is modified to protect against hazards detected and to provide for site emergencies that may occur.

Essentially, the site-specific safety plan is a "living document." It must reflect current conditions at the site and could be revised every day or even every shift, if the conditions warrant.

Routine Operations

Routine operations are those activities required in responding to an emergency or a remedial action at a hazardous waste site. These activities may involve a high degree of risk, but are standard operations that all incident responses may require.

Safety practices for routine operations closely parallel actuated industrial hygiene and industrial safety procedures. Whenever a hazardous incident progresses to the point where operations become more routine, the associated site safety plan becomes a more refined document. As a minimum, the following must be included as part of the site safety plan for routine operations.

Describe the Known Hazards and Risks

This must include all known or suspected physical, biological, radiological, or chemical hazards. It is important that all health-related data be kept up-to-date. As air, water, soil or hazardous substance monitoring and sampling data becomes available, it must be evaluated, significant risk or exposures to workers noted, potential impact on public assessed, and changes made to the plan as necessary. These evaluations need to be repeated regularly since the majority of the plan is based on this information. (Note: I would recommend that many of the hazards at sites are typical hazards that one would expect to be at a work site. These should be listed and then anything out of the ordinary should also be listed. Don't be afraid of putting too much in this section, as you never know what you might run into.)

List Key Personnel and Alternates

The plan must identify personnel (and alternates) responsible for site safety and other essential tasks. It should also identify critical personnel assigned to various site operations. Telephone numbers, (cellular, office, pagers, etc.) address, and organizations of these people must be listed in the plan and posted in a conspicuous place. (Note: I like to keep this section in an Appendix to the plan. This is a section that frequently changes and would therefore be easier to change without a formal review, when a phone number or person changes positions. This works for me, but it may not work for you or your organization. Please use a system that works for you.)

Designate Levels of Protection to be Worn

The Levels of Protection to be worn at locations on-site or by work functions must be selected. This includes the specific types of respirators, cartridges or filters and clothing to be worn for each level. No one will be permitted in any areas requiring personal protective equipment unless they have been trained in its use and are wearing it properly. (Note: I usually include Level A, B, C and D in this section. You can always upgrade or downgrade as needed. This way you are covered regardless of what level of protection is needed.)

Delineate Work Areas

Work areas (exclusion or hot zone, contamination reduction or warm zone, and support or cold zone) need to be designated on the site map and the map placed in the plan. The site of zones, zone boundaries, and access control points into each zone must be marked and made clear to all site workers. (Note: Again, each site is different and may require special markings for work zones. Some may use caution tape, while others may have a worker advising people that they may not enter the area unless authorized.)

List Control Procedures

Control procedures must be implemented to prevent unauthorized access. Site security procedures—fences, signs, caution or safety tape, security or police patrols, and check-in stations and procedures—must be established. Procedures must be also

Figure 3.2 Work zone being set up by personnel

Figure 3.3 Sign depicting the need for protective equipment to be worn in the area

established to control authorized personnel into work zones where personal protective equipment is required. (Note: As we are dealing with hazardous materials/waste, not everyone is allowed on the property. Signs must indicate that fact and perhaps point out some of the hazards on the site.)

Establish Decontamination Procedures

Decontamination procedures for personnel and equipment must be established. Everything (tools, vehicles, equipment, etc.) going into the hot zone must be decontaminated before leaving the hot zone (or disposed of as hazardous waste). Arrangements must also be made for the proper disposal of contaminated material, solutions and equipment. A licensed cleanup and disposal contractor must be utilized for proper disposal. (Note: These procedures are very important, as decontamination will help to prevent the spread of contamination. As long as everyone understands the procedures and someone is assigned to enforce the decontamination efforts, there should be no problem.)

Address Requirements for an Environmental Surveillance Program

A program to monitor site hazards must be implemented. This would include air monitoring and sampling, as well as other kinds of sampling (soil, water, etc.) at or

Figure 3.4 Decontamination efforts take place for workers who have just left a contaminated river site, where they had previously concluded dive operations.

Figure 3.5 Sometimes a site will be discovered where the hazardous substances and associated threats are unknown. In these cases, personnel will use sampling, such as of the contents of this abandoned drum, to determine the health threats and the need for emergency response.

around the site that would indicate chemicals present, associated hazards, possible migration off the site and related safety requirements.

Specify Any Routine and/or Special Training Required

Personnel must be trained not only in general safety procedures and safety equipment, but in any specialized work they may be expected to do. This would include confined space, lock out and tag out, forklift operations, as examples. Supervisory personnel are also required to undergo additional training as needed. (Note: Hazardous waste sites offer distinctive challenges to workers, and often call for specialized training for employees. Of course all employees will need the Hazwoper training and depending on the task(s) they have been assigned, additional courses may be needed.)

Establish Procedures for Weather-Related Problems

Weather conditions can greatly affect site work. Temperature extremes, high winds, storms, etc., impact on personnel safety. Safe work practices must be established to protect workers from the effects of weather and shelters should be provided when necessary. Temperature extremes, especially heat and its effect on workers wearing

Figure 3.6 Classroom training for Hazardous Materials

Figure 3.7 Workers prepare to remove debris from site. Note the clothing, including hats. One can tell by looking at this photo that the weather is not being cooperative.

protective clothing, must be considered and procedures established to monitor for and minimize heat stress.

On Site Emergencies

The plan must address site emergencies—events that require immediate actions to avoid additional problems or harm to responders, the public, property, or the environment. In general, all responses pose a degree of risk to the workers. It is the needless risk that we strive to keep away from. During routine operations, risk is minimized by establishing first-rate work practices and properly using personal protective equipment. Unpredictable events such as fire, chemical exposure, or physical injury may take place and should be anticipated. The plan must contain contingencies for managing these situations. (This is the section of the plan that I call the "What if" section. What if there's a fire or spill? What if someone is injured? What if it's a serious injury? Ask and answer each of these questions and that should assist you with the composition of this section of the plan. You have to anticipate that some of these may actually occur and then prepare to deal with the emergencies.)

Establish Site Emergency Procedures

This is a key section of the plan. There can be no mistakes in this part. It deals with life or death situations, so double check this section to ensure that all bases are covered. This section should:

- List the names and emergency function of on-site personnel responsible for emergency actions along with the special training they have.
- Post the location of nearest landline telephone (if none at site).

Figure 3.8 This type of Emergency Response Vehicle is used at many large incidents as Mobile Command center.

- Provide alternate means for emergency communications. (This could include hand signals, radios, etc.)
- Provide a list of emergency service organizations that may be needed. Names, telephone numbers, and locations must be posted. Arrangements for using emergency organizations should be made ahead of time.

Organizations that might be needed are:

- Fire Department
- Police Department
- Board of Health
- Explosive Experts
- Local Hazardous Material Response Units
- Emergency Management agencies
- Rescue Squads or ambulance services
- Others, depending on situation

Address and define procedures for the rapid evacuation of workers. Clear, audible warning signals should be established, well-marked emergency exits located throughout the site, and internal and external communication plans developed. Codes that could be used for emergency operations based on direct-reading instruments should be discussed with personnel prior to work commencing.

A complete list of emergency equipment should be attached to the safety plan. This list should include emergency equipment available on-site, as well as all available medical, rescue, transport, fire-fighting, and spill and leak equipment. Table 3.1 lists some of the possible equipment.

Figure 3.9 Explosive technicians can be very helpful when bombs or other explosive devices are found at sites.

Address Emergency Medical Care

After answering some of the "What if "questions, this section will deal with the medical care that might be needed:

- Determine location of nearest medical or emergency care facility.
- Determine their capability to handle chemical exposure cases.
- Arrange for treating, admitting, and transporting of injured or exposed workers.
- Post the medical or emergency care facilities location, travel time, directions, and telephone number.

TABLE 3.1 Equipment Checklist

Equipment	Location on site
Fire extinguisher	
Eye wash station	
First Aid Kit	
Sun Block	
Portable oxygen	
Tripod	
Stokes stretcher	
Emergency response guide book	
Glove compartment of truck	
Spill pads	
Booming materials	
Non sparking tools	
Plug kit	
Fire blanket	
Winch	
Drain blocker	

- Determine local physician's office location, travel directions, availability, and post telephone numbers if other medical care is not available.
- Determine the nearest ambulance service and post the telephone number.
- List responding organizations, physicians, safety officers, and toxicologist's names and telephone numbers. Also include the nearest poison control center, if applicable.
- Maintain accurate records on any exposure or potential exposure of site workers during an emergency (or routine operations). The minimum amount of information needed (along with any medical test results) for personnel exposure records should be kept in a locked file cabinet.
- Advise workers of their duties during an emergency. In particular, it is imperative that the site safety officers, standby rescue personnel, decontamination workers, and emergency medical technicians practice emergency procedures.
- Incorporate into the plan, procedures for the decontamination of injured workers and for either transport vehicles or medical care facilities. Whenever feasible these procedures should be discussed

Figure 3.10 It is important to include the directions to the nearest medical facility in the safety plan.

with appropriate medical personnel in advance of operations.

- Establish procedures in cooperation with local and state officials for evacuating residents who live near the site.

IMPLEMENTATION OF THE SITE SAFETY PLAN

The Site Safety Plan (standard operating safety procedure or a generic safety plan for emergency response) must be written to avoid misinterpretation, ambiguity, and mistakes that verbal orders, sometimes, cause. Qualified personnel must review and approve the site safety plan. Once the safety plan is put into service, it needs to be periodically examined and modified, if necessary, to reflect any changes in site work and conditions. Current conditions have to be reflected in the plan, and this is the reason that the plan needs periodic review and revision. Table 3.2 indicates some conditions that will require the plan to be modified.

Figure 3.11 All site phones should have a sticker to remind personnel that 911 is the emergency phone number.

TABLE 3.2 Reasons for Modifying the Safety Plan

Seasonal changes that were not previously addressed
Previously unknown materials/drums unearthed
Pressure washer operations not covered in plan
New equipment being used
Additional hazards identified by site personnel
Confined space entry is now required on this site
Suspicious object found
Decontamination procedures change
Zone locations are relocated
Police Officers are now required for site security reasons
New cleaner is added to the operation (MSDS attached)
Additional tasks have been identified by the client and need to be added to plan

All agencies and organizations which have an active role at the incident must be familiar with the plan. If possible the plan should be written in coordination with the organizations involved. To the extent possible, lead personnel from these organizations should sign the plan to suggest they agree with it and will follow its provisions.

TABLE 3.3 Recommended Training by Job Category

Training Topic	Emphasis of Training	General Site Worker	Onsite Management & Supervisors	Health & Safety Staff	Visitors
Biology, Chemistry, and Physics of Hazardous Materials	Chemical and physical properties; chemical reactions; chemical compatibilities.	R	R	R	
Toxicology	Dosage routes of exposure, toxic effects, immediately dangerous to life or health (IDLH) values, permissible exposure limits (PELs), recommended exposure limits (RELs), threshold limit values (TLVs).	R	R	R	
Industrial Hygiene	Selection and monitoring of personal protective clothing and equipment.		R	R	
–	Calculation of doses and exposure levels; evaluation of hazards; selection of worker health and safety protective measures.		R	R	
Rights and Responsibilities of Workers Under OSHA	Applicable provisions of Title 29 of the Code of Federal Regulations (the OSHA Act).	R	R	R	
Monitoring Equipment	Functions, capabilities, selection, use limitations, and maintenance.	R	R	R	

(continues)

TABLE 3.3 Recommended Training by Job Category ***(continued)***

Training Topic	Emphasis of Training	General Site Worker	Onsite Management & Supervisors	Health & Safety Staff	Visitors
Hazard Evaluation	Techniques of sampling and assessment.		R R		
	Evaluation of field and lab results.		R	R	
	Risk assessment.		O	R	
Site Safety Plan	Safe practices, safety briefings and meetings. Standard Operating Procedures, site safety map.	R	R	R	R
Standard Operating Procedures (SOPs)	Hands-on Practice.	R	R	R	
	Development and compliance.		R	R	
Engineering Controls	The use of barriers, isolation, and distance to minimize hazards.	R	R	R	
Personal Protective Clothing and Equipment (PPE)	Assignment, sizing, fit-testing, maintenance, use, limitations, and hands-on training.		O	R	
	Selection of PPE.			R	
	Ergonomics.				
Medical Program	Medical monitoring, first aid, stress recognition.	R	R	R	
	Advanced first aid, cardiopulmonary resuscitation (CPR); emergency drills.	O	R	R	
	Design, planning and implementation.		R		

TABLE 3.3 Recommended Training by Job Category ***(continued)***

Training Topic	Emphasis of Training	General Site Worker	Onsite Management & Supervisors	Health & Safety Staff	Visitors
Decontamination	Hands-on training using simulated field conditions.	R	R	R	
	Design and maintenance.	R	R	R	
Legal and Regulator Aspects	Applicable safety and health regulations (OSHA, EPA, etc.)	O	R	R	
Emergencies	Emergency help and self-rescue; emergency drills.	R	R	R	
	Response to emergencies; follow-up investigation and documentation.		R	R	

[a]R = Recommended
O = Optional

All personnel involved at site must be familiar with, review, and understand the safety plan, or the parts that pertain to their specific activities. Frequent safety meetings should be held to keep all informed about site hazards, changes in operating plans, modifications to the safety plan and for exchanges of information. It is the responsibility of personnel involved at the site as workers or visitors to comply with the requirements in the plan.

There is not a company in the world that, in my opinion, cannot spare a few minutes every day for a safety briefing. I do not mean that a person needs to have a TV/VCR and a PowerPoint presentation every day, and sit in a classroom for four hours before going to work, but a few minutes before the work starts each day is important to get a safety message across to all the workers. Table 3.3 outlines some of the applicable training for workers involved in hazardous waste operations.

Frequent audits by the project manager and/or the safety officer should be made to determine compliance with the plan's requirements. Any deviations should be brought to the attention of the project manager at once, so that they may be corrected. Modifications in the plan should be reviewed and approved by appropriate personnel.

TYPICAL SAFETY PLAN OUTLINE

This outline can be used to develop your site specific safety plan. Please include other items that may be distinctive to your company or operations, and eliminate or revise items that are not relevant.

1.0 INTRODUCTION
- Purpose
- Scope of Work
- Use of the Plan
- Responsibilities
- Other

2.0 SITE / HAZARD CHARACTERIZATION
- Materials of Concern
- Chemical Exposure
- Confined Space Issues
- Physical Hazards / Stresses
- Risks Associated by the Site Operation/Mitigation Actions
- Other

3.0 TOXICOLOGY / REGULATOR COMPLIANCE
- Definition of Terms

Toxicology Data Regarding Site Hazards
Standard and Recommended Guidelines
Permissible Exposure Limits Regarding Site Hazards

4.0 SITE CONTROL
Site Map
Site Preparation
Standard Operating Procedures
Support Zone (cold)
Contamination Reduction Zone (warm)
Exclusion Zone (hot)

5.0 MONITORING PROGRAM
Chemical Hazard Sampling Strategy and Methodology
Chemical Hazard Analyses Methodology
Physical Hazard Sampling Strategy and Methodology
Physical Hazard Analyses Methodology

6.0 WORKER PROTECTION PROGRAM
Respiratory Protection Plan
Selection of Personal Protective Equipment
Upgrading and Downgrading PPE Levels
Work Schedule Regime (Heat Stress)
Other Safety Factors
Record keeping and Documentation

7.0 MEDICAL SURVEILLANCE PROGRAM
Site-specific Initial Medical Screening (when necessary)
Site-specific Termination Medical Screening (when necessary)
Ability to Don PPE

8.0 DECONTAMINATION PROCEDURES
Prevention of Contamination
Methods for Decontamination
Worker Decontamination Procedures
Equipment Decontamination Procedures
Sample Decontamination Procedures
Life-Threatening Situations

9.0 TRAINING PROGRAM
Contents of Training Provided
Compliance with Regulatory Standards
Personnel Requiring Training

10.0 EMERGENCY RESPONSE PLAN
On-Site Emergency Medical Care
Off-Site Emergency Medical Treatment
On-Site Emergency Response Procedures
Off-Site Emergency Response Procedures

11.0 TRANSPORTATION AND DISPOSAL OF WASTE MATERIALS
Handling Procedures
Transportation Route
Disposal Site
Toxic Characteristic Leachate Profile (TCLP) Results
Profile Acceptance Number

RESPONSIBILITIES

With every project come duties and responsibilities for various workers. This is especially true when speaking about hazardous waste sites. There are a variety of people involved with a hazardous waste operations, each having accountability for his/her functional area. Table 3.3 shows some of the essential personnel involved in the daily operations. Some of the key players are listed below.:

Client

The client has the following responsibilities (not all inclusive):

- Responsible for direct emergency response operations relating to soil sampling activities, according to the Corporate Health and Safety Plan.
- Provides the necessary facilities, equipment, and site access.
- Incurs costs to implement work according to the SSP.
- Provides permission for site access and coordinates activities with appropriate client officials.
- Provides adequate time resources to conduct on-site activities safely.
- Has authority to remove any person(s) whose work constitutes unsafe work practices.

- Controls the decontamination of all equipment, personal protective equipment, and samples from the contaminated areas in conjunction with the engineering firm.
- Responsible for the transportation and disposal of all contaminated materials (i.e., wash water and solids).

Engineering Firm

The engineering firm has the following responsibilities (not all inclusive):

- Conduct on-site operations as described in the work plan.
- Ensures that all samples are collected, processed, and analyzed in a proper manner.
- Manages the field operations of the site-contracting firms.
- Briefs the field team on their specific assignments.
- Ensures that all required equipment is available and used appropriately.
- Documents field activities.
- Has authority to remove any person(s) whose work constitutes unsafe work practices.

Site Contractors

Contractors perform the bulk of the work at many hazardous waste sites. They have enormous responsibilities which may include but not be limited to:

- Completes on-site tasks as sub-contractor to the general on-site
- Safely completes the on-site activities as directed by the Engineering Firm in accordance with the Work Plan.
- Complies with the Site Safety Plan.
- Notifies the Site Safety Officer or Engineering Firm Supervisor of unsafe conditions.
- Performs decontamination of all equipment and protective clothing.

Consulting Firm / Site Safety Officer (SSO)

The SSO plays a crucial role in all aspects of project management and may include responsibilities (mot all inclusive) like:

- Advises the Engineering Firm Supervisor on all aspects of on-site health and safety.

- Recommends and has total authority for stopping work if any operation threatens worker and/or public health or safety.
- Assists the client as a liaison with public officials.
- Selects protective clothing and equipment and monitors the use of such equipment.
- Coordinates the collection of any pre and post medical tests required specifically for the site.
- Provides emergency response treatment procedures (i.e., CPR and First Aid) until appropriate emergency personnel arrive.
- Confirms each team members' suitability for work based on a physician's recommendations.
- Sets up decontamination lines and the decontamination solutions appropriate for the type of chemical contamination on site.
- Monitors the work parties for signs of physical stress (i.e., heat stress and fatigue).
- Monitors and documents on-site hazards and conditions.
- Notifies emergency response personnel by telephone, radio or other means in the event of an emergency.
- Coordinates emergency medical care, both on and off site.
- Knows and utilizes, if necessary, emergency procedures, evacuation routes, and the telephone numbers of the ambulance, local hospital, poison control center, fire department, and police department.
- Conducts continuous inspections to determine compliance with the Site Safety Plan.
- Controls entry and exit at the access points into the disturbance or Exclusion Zone.

SUMMARY

Safe work practices need to be carefully planned with detailed written work instructions or programs that provide workers with guidelines to safely perform their job assignments. The safety plan and standard operating procedures are administrative controls that help to minimize risks to employees, the environment and any nearby communities.

Although every hazardous waste operation possesses unique characteristics, similar techniques are used to work with power tools, prevent back injuries, as well as to prevent the spread of contamination. Management needs to ensure that the plans and procedures that are out into place are actually being followed. Employees need to abide by all established safety rules for the workplace and submit recommendations for improvement of the safety rules, if needed.

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE MANUAL
by Brian J. Gallant

4

SITE CHARACTERIZATION

Site characterization, sometimes referred to as site assessment, provides the information needed to identify site hazards and to select worker protection methods. The more precise, detailed, and comprehensive the information available about a site, the more the protective measures can be customized to the actual hazards that workers may encounter.

The person with primary responsibility for site characterization and assessment is the Project Team Leader (or similarly titled person in your organization). Additionally, outside experts, such as geologists, industrial hygienists, toxicologists, and health physicists may be needed to accurately and fully interpret all the available information about the site. (The Project Team Leader is responsible for the assessment, but will not be expected to perform all of the work alone.)

Site characterization generally progresses in three phases:

- Offsite characterization- done prior to site entry (gather information away from the site and conduct investigation from the site perimeter)
- On site surveys- during this phase, access should be restricted to inspection personnel
- Ongoing monitoring- once the site has been determined safe for initiation of other activities, this phase provides a continuous source of data about the site conditions

It is important to recognize that site characterization is a constant process. At each phase of site characterization, information should be obtained and evaluated to further define the hazards that the site may pose. This assessment can then be used to

Figure 4.1 A geologist monitors the groundwater and enters the data into a laptop computer for documentation.

develop a site-specific health and safety plan for the next phase in the operation. Over and above the information gathering that takes place during the phases of characterization of the site described in this chapter, all site personnel should be constantly alert for new information about site conditions.

The following sections detail the three phases of site characterization and provide a general guide that should be modified to meet the specific situation. Readers should keep in mind that each site will be different, and as a result, each site poses unique and challenging situations to workers. Within each phase of information gathering, the most appropriate sequence of steps should be determined, particularly if there are time or budget constraints that might limit the scope of the work. Whenever possible, all information sources should be followed.

OFFSITE CHARACTERIZATION

The goal of offsite characterization is to gather and evaluate as much information as possible before any personnel enter the site, so that preliminary controls can be established to protect all entry personnel. Initial information gathering assignments should center on identifying all potential or suspected conditions that may pose inhalation hazards that are immediately dangerous to life or health (IDLH) or other conditions that may cause or are likely to cause death and/or serious injury.

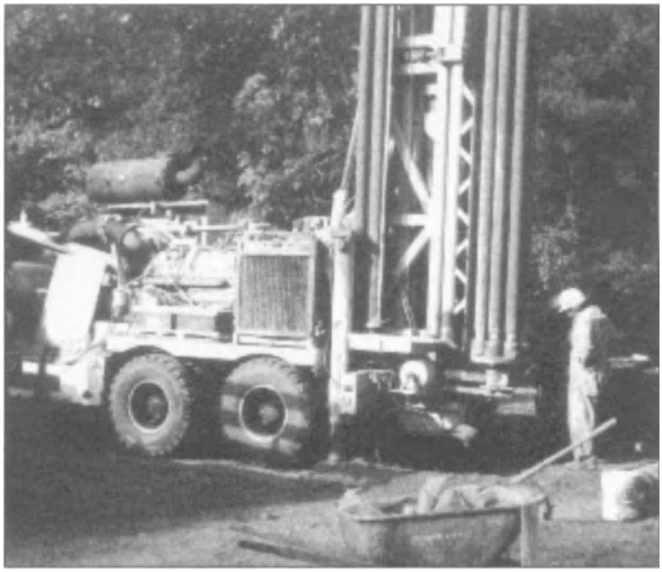


Figure 4.2 A drill unit operator is performing on site characterization. He will use the drill to obtain core samples of the contaminated soil.

Offsite information can be obtained by two techniques:

- Interview/records research
- Perimeter investigation

Interview/Records Research

As much data as possible should be collected before any on site activities commence. To the extent possible, the following information should be acquired:

- Exact location and site description
- Detailed description of activities that took place at the site
- Extent of the activities
- Weather and forecast information (wind direction, precipitation levels, temperature summaries)
- Access to site by road or air
- Terrain features (land use maps, site photographs, etc.)
- Geological information (US Geological Survey, etc.)

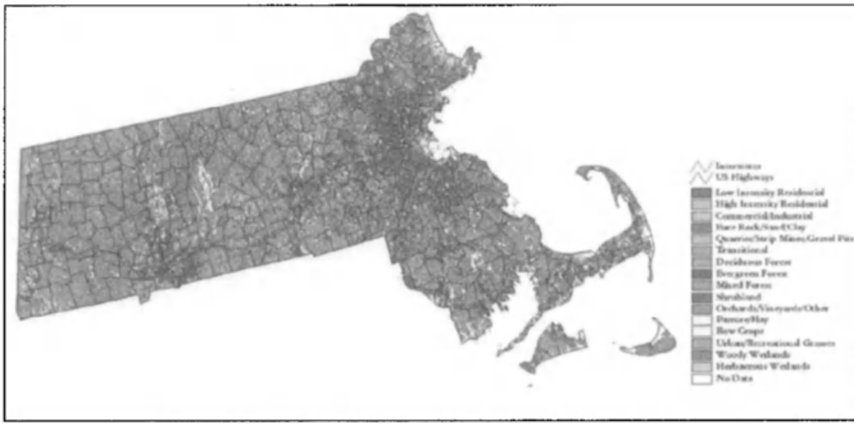


Figure 4.3 A land use map, like the one above, can be used in site characterization.

- Population data (who may be at risk nearby?)
- Hazardous substances involved and their chemical and physical properties

Information sources for these include:

- Company records, log books, receipts
- Waste storage inventories, including manifests and shipping papers
- Generator and transporter documentation
- Water and sewer records
- Records from local, state and federal regulatory agencies, State Fire Marshal's Office, State Attorneys General Office, Occupational Safety and Health Officials, Health departments
- Consultation with employees, retirees and their families (all information must be verified, as there could be disgruntled people involved in this audience)
- Interviews with neighbors, community residents and leaders (note any possible health related issues that might arise in these discussions, and verify as above)
- Local fire, police and building department records
- Court information (Registry of Deeds)
- Utility records
- Media reports (verify all of these)
- Previous environmental survey or assessment results

Figure 4.4 The US Geological Survey has a variety of maps and other documents that may prove helpful on many sites.

Perimeter Investigation

At a site where hazards are mainly unknown or there is no need to enter the site immediately, visual observations should be made, atmospheric concentrations of airborne contaminants at the site's perimeter should be monitored closely, and sampling should be done near the site (water, soil, groundwater). While these data points are not all inclusive of all onsite conditions, they can aid in the initial evaluation process. Perimeter investigation of a site should involve the following actions:

- Develop a preliminary site map (can be hand drawn), with locations of out buildings, tanks, containers, pits, ponds, etc.
- Review current as well as historical photos. Note:
  - Disappearance of natural depressions, quarries, or pits
  - Variations in any disturbed areas
  - Mounding or uplifting of soil or paved areas/modifications in grade
  - Changes in vegetation
  - Alterations to traffic patterns at the site
- Note any labels, markings, or placards on vehicles, containers, tanks
- Note the condition or damage to containers or tanks or vehicles
- Note any biological indicators, such as dead plants, animals, or vegetation
- Note unusual conditions, such as clouds, discolored liquids, pooled liquids, effervescence, or other suspicious substances

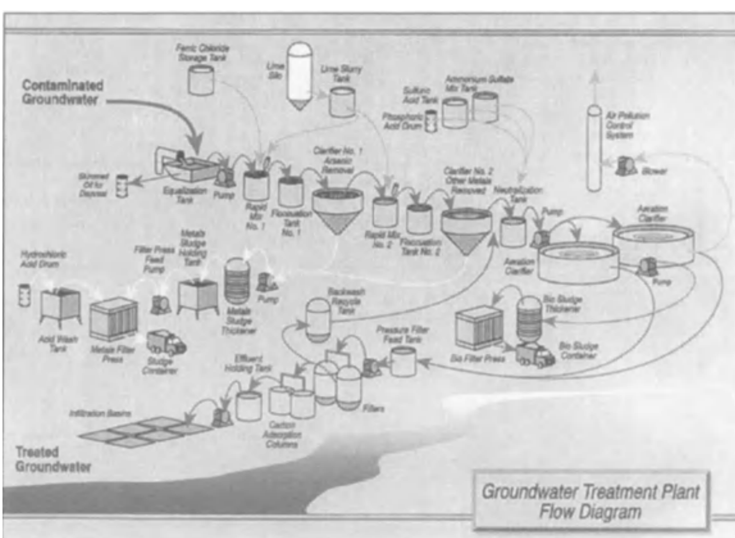


Figure 4.5 This site map can be used in your safety plan as well as for assessment work.

Figure 4.6 These mounds of soil have to be sampled to determine what contaminants are present.

Figure 4.7 Changes in vegetation are easy to identify. They usually help to put the pieces to the puzzle together. There is a reason why there is a change. Now it is the scientist's job to determine what the reason is.

- Note any unusual odors
- Monitor the air at the site's perimeter for:
  - Toxic materials
  - Oxygen deficient atmosphere
  - Ionizing radiation levels
  - Combustible/flammable gases
  - Any specific hazardous materials that are known to be on site

Personnel should collect and analyze any offsite samples that may be collected, including the following:

- Soil
- Ground water
- Drinking water, if present
- Site run off, if present
- Surface water

PROTECTION OF SITE ENTRY WORKFORCE

The information gathered during records search, interviews, and perimeter investigation is used as the basis for selecting the most appropriate personal protective equip-

Figure 4.8 Pooled liquid, as shown above, is a good indicator that there is a problem in that general area. The source of the liquid has to be found.

Figure 4.9 Sampling was taken from this area in Massachusetts due to ground water contamination. Note the change in vegetation and discolored soil.

ment (PPE) for the initial site examination. The Project Team Leader and his expert team must also consider the proposed work to be accomplished. For example, if the intent of the examination is to inspect onsite conditions, inventory containers, monitor the air for "hot spots" (areas with high levels of contamination), and generally become familiar with the site layout, the level of protection may be less stringent than if containers were going to opened and checked for contents and/or samples taken.

Level B protective clothing and equipment is the minimum level of protection recommended for entry until the site hazards have been further identified and confirmed, and the most appropriate protective gear and equipment chosen.

ONSITE SURVEY

The purpose of an onsite survey is to confirm and supplement information gathered in the offsite characterization. Prior to entering the site, the offsite characterization should be used to develop a site safety plan for site entry that addresses the work to be accomplished and stipulates the procedures to protect the health and safety of the entry crew. Priorities should be established for hazard assessment and site activities after careful evaluation of likely conditions. As team members may be entering a largely unknown environment, care, caution and conservative actions are appropriate.

Figure 4.10 These workers are operating in Level B chemical protective equipment.

The makeup of the entry team depends on the site characteristics, but should always consist of at least four persons: two workers who will enter the site and two outside support persons suited in personal protective equipment and prepared to enter the site in the event of an emergency. (Note the buddy system is being used. Personnel should never perform any work alone.) Upon entering the site, entry personnel should:

- Perform air monitoring for IDLH and other conditions that may cause death or serious injury (flammable or explosive atmospheres, oxygen deficient atmospheres, toxic materials) Table 4.1 indicates some IDLH and other dangerous considerations.
- Monitor for ionizing radiation. Survey for gamma and beta radiation with a Geiger-Mueller detection tube or a gamma scintillation tube; if alpha radiation is expected, then use a proportional counter.
- Visually observe for signs of actual or possible IDLH or other hazardous conditions

Any indication of IDLH hazards or other dangerous conditions should be regarded as a sign to proceed with care and caution. Extreme vigilance should be exercised in continuing the site survey when such hazards are indicated. If IDLH or other dangerous conditions are not present, or if proper precautions can be taken, then continue the survey.

Table 4.1 Visible Indicators of Potential IDLH and Other Dangerous Conditions

- Large containers or tanks that must be entered.
- Enclosed spaces such as buildings or trenches that must be entered.
- Potentially explosive or flammable situations (indicated by bulging drums, effervescence, gas generation, or instrument readings).
- Extremely hazardous materials (such as cyanide, phosgene, or radiation sources).
- Visible vapor clouds.
- Areas where biological indicators (such as dead animals and/or vegetation) are located.

Continuing the Survey

Be sure to conduct further air monitoring as needed.

- Note the type of containers or other storage systems:
  - Paper or wooden packaging
  - Above ground storage tanks
  - Underground storage tanks
  - Metal or plastic barrels or drums
  - Pits, ponds, bodies of water
  - Compressed gas cylinders
  - Other

Note the condition of waste containers and storage systems:

- Intact (undamaged)
- Visibly rusted or corroded
- Leaking
- Bulging
- Types of quantities of materials in containers
- Labels on containers indicating corrosive, explosive, flammable, radioactive, or toxic materials

Note the physical condition of the materials:

- Gas, liquid and solid
- Color and turbidity
- Behavior (e.g. corroding, foaming, or vaporizing)
- Conditions conducive to splash or contact

Figure 4.11 These above ground storage tanks have been abandoned for many years. Now personnel must determine what actions to take to clean the site.

Remember to identify any natural wind barriers:

- Buildings
- Hills
- Tanks

Attempt to determine the potential pathways of dispersion:

- Air
- Biological routes, such as animals and food chains
- Ground water
- Land surface
- Surface water

If necessary, use one or more of the following remote sensing or subsurface investigative methods to locate buried wastes or contaminant plumes:

- Ground-penetrating radar
- Magnetometer
- Metal detection

Figure 4.12 Ground penetrating radar is used to detect the presence of buried tanks and drums.

Take note of any indicators of potential exposure to hazardous substances, such as:

- Dead fish, animals or vegetation
- Dust or spray in the air
- Splits or cracks in solid surfaces that expose deep waste layers
- Pooling liquid
- Effervescence or oils on liquid surfaces
- Gas generation
- Deteriorating containers
- Cleared land area or possible land filled areas

Of special note, should be any safety hazards that may be identified. Consider the following:

- Conditions of site structures
- Obstacles to entry and exit
- Terrain homogeneity
- Terrain stability
- Stability of stacked materials

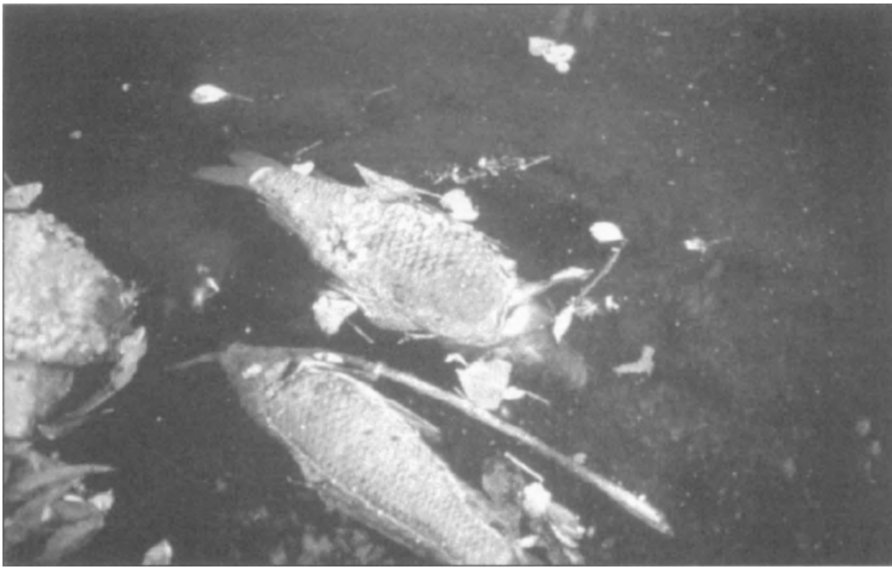


Figure 4.13 Dead fish indicate problems with the water. Samples will be taken from this pond to determine the cause of the fish kill.

Figure 4.14 Stacked drums

Make every attempt to identify any reactive, incompatible, flammable, or highly corrosive materials. Note the land features. Also, make a note of the presence of any potential naturally occurring skin irritants or dermatitis-inducing agents, for example:

- Poison ivy
- Poison oak
- Poison sumac

Note any tags, labels or other identifying indicators. Collect samples: (Table 4.2 gives guidelines for some atmospheric hazards)

- Air
- Drainage ditches
- Soil (surface and subsurface)
- Standing pools of liquids
- Storage containers
- Streams and ponds
- Groundwater (upgrade, beneath site, downgrade)

Take samples of or otherwise identify any of these:

- Biological hazards
- Radiological hazards

Information Documentation

Proper documentation and document control are extremely important for ensuring accurate communication, ensuring the quality of the data collected, providing the rationale for safety decisions, and substantiating possible legal actions. Documentation can be accomplished by recording information relevant to field activities, sample analysis, and site conditions in one of several ways, including:

- Logbooks
- Field data records and notes
- Graphs
- Photographs
- Sample labels
- Chain of custody forms
- Analytical records

Table 4.2 Guidelines for Some Atmospheric Hazards

HAZARD[b]	MONITORING EQUIPMENT[c]	MEASURED LEVEL	ACTION
Explosive Atmosphere	Combustible gas indicator	<10% LEL[d]	Continue investigation.
		10%-25% LEL	Continue onsite monitoring with extreme caution as higher levels are encountered.
		>25% LEL	Explosion hazard. Withdraw from area immediately.
Oxygen	Oxygen Concentration meter	< 19.5%	Monitor wearing self-contained breathing apparatus. NOTE: Combustible gas readings are not valid in atmospheres with < 19.5% oxygen.
		19.5% - 25%	Continue investigation with caution. Deviation from normal level may be due to the presence of other substances.
		> 25%	Fire hazard potential. Discontinue investigation. Consult a fire safety specialist.
Radiation	Radiation Survey Equipment	# 2 mrem/hr[e,f]	Radiation above background levels (Normally 0.01 - 0.02 mrem/hr)[g] signifies the possible presence of radiation sources. Continue investigation with caution. Perform thorough monitoring. Consult with a health physicist.
		> 2 mrem/hr.	Potential radiation hazard. Evacuate site. Continue investigation only upon the advice of a health physicist.
Inorganic and organic gases and vapors	Calorimetric tubes Chemical-specific Instruments, including halide meter, hydrogen sulfide detector, carbon monoxide monitor, and mercury meter.	Depends on Chemical.	Consult standard reference manuals for air concentration/toxicity data. Action level depends on PEL/REL/TLV[h].
Organic gases and vapors	Portable photo ionizer Organic vapor analyzer 1) Operated in gas chromatography. 2) Operated in survey mode.	Depends on chemical	Consult standard reference manuals for air concentration/toxicity data. Action level depends on PEL/REL/TL.

These documents should be controlled to make certain that they are all accounted for when the project is completed. The task of document control should be assigned to one individual on the project team and should include the following responsibilities:

- Listing each document in a document inventory
- Numbering of each document (including sample labels) with a exclusive number
- Collecting all documents at the end of each shift
- Tracking each member of the project team that has or should have documents in their possession
- Filing all documents in a central file at the completion of the site response
- Making sure that entries are made in legible ink (preferably waterproof)

Figure 4.15 Field notebooks are used to document findings. Note that this model is hardbound.

The field personnel should record all onsite activities and observations in a field notebook (bound book with consecutively numbered pages are recommended). This will prevent pages from being lost, arranged in the improper order, or giving the impression that documents have been improperly revised. Entries should be made during or just after completing the task to guarantee thoroughness and accuracy.

Photographs can be an accurate, objective addition to the field worker's written inspection. For each photograph taken, the following information should be recorded in the field notebook: (Table 4.3 shows some of this information)

- Name of site, date, and time taken
- Photographer's name
- Location of the subject within the site
- Compass direction of the orientation of the photograph
- Sequential number of the photo
- Camera, lens, and film type used

Serially numbered sample labels or tags should be assigned to sampling personnel and recorded in the field notebook. Any labels that are lost, voided or damaged should also be recorded in the notebook. Labels should be firmly affixed to the sample container(s) using a gummed label or tag attached to the container by string or wire. Information should be recorded on the tag in waterproof ink and should include items such as:

- Unique sample log number
- Date and time the sample was taken

- Person collecting the sample
- Source of the sample (location and type of sample)
- Preservative used
- Analysis used
- Any other field data that may be important

Table 4.3 Information to be Recorded

- Date and time of entry.
- Purpose of Sampling.
- Name, address, and affiliation of personnel performing sampling.
- Name and address of the materials produced, if known.
- Type of material, e.g., sludge or wastewater.
- Description of sample.
- Chemical components and concentrations, if known.
- Number and size of samples taken.
- Description and location of the sampling point.
- Date and time of sample collection.
- Difficulties experienced in obtaining the sample (e.g. is it representative of the bulk material?)
- Visual references, such as maps or photographs of the sampling site.
- Field observations, such as maps or photographs of the sampling site.
- Field measures of the materials, e.g. explosiveness, flammability, or ph.
- Whether Chain-of-Custody forms have been filled out for the samples.

In addition to supporting litigation, written records of sample collection, transfer, storage, analysis, and destruction help ensure the proper interpretation of analytical test results. Information describing the chain of custody should be recorded on a form that accompanies the sample from collection to destruction. (Figure 4.16)

Hazard Assessment

Once the presence and concentrations of specific chemicals or classes of chemicals have been established, the hazards associated with these chemicals must be determined. This is done by referring to standard reference sources for data and guidelines on permissible levels of exposure, flammability, etc.

Threshold Limit Values

Threshold Limit Values (TLV's) can be used as a guideline for determining the appropriate level of worker protection. These values have been derived for many substances and can be found in *Threshold Limit Values for Chemical Substances and*

CNA Environmental Inc.
446 Maple Avenue
Saratoga Springs, N.Y. 12866
(518) 581-7610

FAX# (518) 584-4481

Chain of Custody Form

Owner Name & Property Address of Site Sampled	Contact Phone	Person taking sample(s)
	Public Water Supply#	Sample Source (well, pond, etc)
	Type:(DW=drinking water, WW=wastewater, etc.)	

Lab Sample ID	Sample Point	Date	Time	Sample Type	# of Cont.	Analysis Required

The NYS Department of Health recommends that you test your well annually and/or any time that the well may have been contaminated. Do you want us to send sample bottles to your mailing address in one year? YES NO
(please circle yes or no)

Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
Received for Laboratory by:		Date/Time

Method of shipment:	Method of Paymen	
Mailing Address:	Comments:	Chlorine Resid.:

Figure 4.16 Chain of Custody Form

Physical Agents, which is published annually by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH is a private group and defines three categories of TLV's:

- Time weighted average (TWA)
- Short term exposure limit (STEL)
- Ceiling (C)

Personnel must adhere to the Permissible Exposure Limits (PEL) (see below), as they are the OSHA regulatory levels, but can use the TLV's without fear of fines or violations. The TLV's can be used as guidance, and are often the information provided to workers in Material Safety Data Sheets or other reference documents. In all cases the TLV are less than or equal to the PEL, so there should be no problem utilizing this data.

Permissible Exposure Limit

Permissible exposure limits are enforceable standards promulgated by OSHA. In most cases, these limits are derived from the TLV's published in 1968. The PEL for a substance is the 8 hour time weighted average (TWA) or ceiling concentration above which workers may not be exposed without proper personal protective equipment. Although personal protective equipment is not required for exposures below the PEL, it is recommended that its use be evaluated where there is a potential for overexposure.

Recommended Exposure Limit

The National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL) is the workplace exposure concentration recommended, but is not enforceable. (Only OSHA's PEL are enforceable.)

IDLH Concentrations

Immediately Dangerous to Life and Health (IDLH) exposure concentrations have been established by NIOSH/OSHA as a guideline for selecting respiratory protection for some chemicals. The definition of IDLH varies depending on the source. As an example, the *"NIOSH Pocket Guide to Chemical Hazards"* defines IDLH concentration as the "...maximum level from which one could escape within thirty minutes without any escape-impairing symptoms or any irreversible health affects..." The Mine Safety and Health Administration Standard, 30 CFR Part 11.3 (t) defines IDLH conditions as those that pose an immediate threat of severe exposure to contaminants such as radioactive materials that are likely to have adverse cumulative or delayed effects on health. Regardless of their exact definition, all IDLH values indicate those concentrations of toxic substances from which escape is possible without irreversible harm should a worker's respiratory protective equipment fail. At hazardous waste sites, IDLH concentrations should be assumed to represent concentrations above which only workers wearing respirators that provide the maximum protection (i.e., positive pressure, full face piece, self-contained breathing apparatus (SCBA) or a combination positive pressure, full face-piece, supplied air respirator with positive pressure SCBA) are permitted. Specific IDLH values for many substances can be found in the "*NIOSH Pocket Guide to Chemical Hazards.*"

Potential Skin Absorption and Irritation

Information on skin absorption is provided in the ACGIH publication, *Threshold Limit Values for Chemical Substances and Physical Agents* and in OSHA's standard, 29 CFR Part 1910.1000 and other standard references. These documents identify substances that can be readily absorbed through the skin, mucous membranes, and/or eyes by either airborne exposure or direct contact with a liquid. This information, like most available information on skin absorption is qualitative. It indicates whether, but not to what extent, a substance may pose a dermal hazard. Therefore, decisions made regarding skin hazards are necessarily judgmental.

In addition, many chemicals, although not absorbed through the skin, may cause skin irritation at the point of contact. Signs of skin irritation range from redness, swelling or itching to burns that destroy skin tissue.

Potential Eye Irritation

Quantitative data on eye irritation is not always available. Where a review of the literature indicates that a substance causes eye irritation, but no threshold is specified, a competent health professional should evaluate the information to determine the level of personal protective equipment for workers engaged in operations exposing them to this hazard.

Flammable and Explosive Range

The lower explosive limit (LEL) or lower flammable limit (LFL) of a substance is the minimum concentration of a gas or vapor in air below which the substance will not burn when exposed to a source of ignition. This concentration is usually expressed in percent by volume. Below this concentration, the mixture is considered "too lean" to burn or explode.

The upper explosive limit (UEL) or upper flammable limit (UFL) of a substance is the maximum concentration of gas or vapor above which the substance will not burn when exposed to an ignition source. Above this concentration, the mixture is "too rich" to burn or explode.

The flammable range is the range of concentrations between the LEL and UEL where the gas-air mixture will support combustion.

The flashpoint of a substance is the minimum temperature at which it gives off sufficient vapor to form an ignitable mixture with air just above the surface of the substance. Ignition of a substance at the flashpoint is not continuous. (It will not sustain combustion.)

Ignition temperature is the minimum temperature required to initiate or cause self-sustained combustion without an ignition source.

When evaluating the fire or explosion potential at a hazardous waste site, all equipment used should be intrinsically safe or explosion proof. Where flammable or explosive atmospheres are detected, ventilation may dilute the mixture to a level below the LEL/LFL. However, ventilation is generally not recommended if concentrations exceed the UEL/UFL, since the mixture will then pass through the flammable/explosive range as it is being diluted. Keep in mind that combustible gas indicator readings may not be accurate when oxygen concentrations are less than 19.5 percent.

MONITORING

Because site activities and weather conditions change frequently, an ongoing air monitoring program should be implemented after characterization has determined that the site is safe for the operations to begin.

The ongoing monitoring of atmospheric chemical hazards should be conducted using a combination of stationary sampling equipment, personnel monitoring devices, and periodic area monitoring with direct reading instruments. Data obtained during offsite and onsite surveys can be used for monitoring ambient conditions during cleanup operations. Where necessary, routes of exposure other than inhalation should be monitored. For example, skin swipe tests may be used to determine the effectiveness of personal protective clothing. Depending on the physical properties and toxicity of the onsite materials, community exposures resulting from hazardous waste site operations may need to be assessed.

Monitoring also includes continual evaluation of any changes in site conditions or work activities that could affect worker health and safety. When a significant change occurs, the hazards must be reassessed. (See Table 4.4) Some indicators of the need for reassessment are:

- Season changes
- Change in tasks during a work phase
- Start of a new phase, such as start of drum sampling phase
- Changes in ambient levels of contaminants

Table 4.4 Hazard Reassessment

HAZARD	GUIDELINE		EXPLANATION	SOURCES FOR VALUES
Inhalation of airborne contaminants	TLV	Threshold Limit Value	One of three categories of chemical exposure levels, defined as follows:	
	TLV-TWA	Threshold Limit Value - Time-Weighted Average	The time-weighted average concentration for a normal 8-hour workday and a 40-hour work week, to which nearly all workers may be repeatedly exposed without adverse effect. Should be used as an exposure guide rather than an absolute threshold.	ACGIH
	TLV-STEL	Threshold Limit Value-Short-Term Exposure Limit	A 15-minute time-weighted average exposure that should not be exceeded at any time during the work day.	ACGIH
	TLV-C	Threshold Limit Value - Ceiling	The concentration that should not be exceeded even instantaneously.	ACGIH
	PEL	Permissible Exposure Limit	Time-weighted average and ceiling concentrations similar to (and in many cases derived from) the threshold limit values published in 1968.	OSHA
	REL	Recommended Exposure Limit	Time-weighted averages and ceiling concentrations based on NIOSH evaluations.	NIOSH
	IDLH	Immediately Dangerous to Life or Health	The maximum level from which a worker could escape without any escape-impairing symptoms or any irreversible health effects.	NIOSH

(continues)

Table 4.4 Hazard Reassessment (*continued*)

HAZARD	GUIDELINE		EXPLANATION	SOURCES FOR VALUES
Dermal absorption of chemicals through airborne or direct contact	Designation Askin≅		The designation: Askin≅ in the ACGIH, OSHA, and NIOSH references indicates that a substance may be readily absorbed through the intact skin; however, it is not a threshold for safe exposure. Direct contact with a substance designated Askin≅ should be avoided.	ACGIH OSHA NIOSH
Dermal irritation			Many substances irritate the skin. Consult standard references.	
Carcinogens	TLV	Threshold Limit Value	Some carcinogens have an assigned TLV.	ACGIH
	PEL	Permissible Exposure Limit	OSHA has individual standards for some specific carcinogens.	OSHA
	REL	Recommended Exposure Limit	NIOSH makes recommendations regarding exposures to carcinogens.	NIOSH
Noise	TLV	Threshold Limit Value	Sound pressure levels and durations of exposure that represent conditions to which it is believed that nearly all workers may be repeatedly exposed without an adverse effect on their ability to hear and understand normal speech.	ACGIH
	PEL	Permissible Exposure Limit	Limits for acceptable noise exposure.	OSHA
	REL	Recommended Exposure Limit	Limits for acceptable noise exposure.	NIOSH
Ionizing Radiation	Maximum permissible body burden and maximum permissible concentrations of radionuclides in air and in water.			NCRP
	PEL	Permissible Exposure Limit	Dose in rems per calendar quarter.	OSH

SUMMARY

Site characterization goes hand in hand with the development of the site specific health and safety plan and site control, as well. The assessment of hazardous waste sites assist personnel with the identification of various hazards that may be encountered during the remediation or sampling efforts. Normally, the assessment is done well in advance of the cleanup efforts.

Personnel involved in the characterization of the site(s) should use the tools and equipment that is available to them. Examples include personal protective equipment, air monitoring instruments and communications equipment. Sufficient samples should be taken and analyzed as needed to help in the determination of specific hazards and quantification of materials.

Every site has different hazards, so never assume that the area is clean. Sampling and documentation are important steps that must be followed for a successful operation.

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE MANUAL
by Brian J. Gallant

5

SITE CONTROL

Hopefully by now, you are beginning to see how all of the chapters fit together to complete the "Hazwoper puzzle." We really cannot discuss Safety Plans without including Site Control and Site Characterization and vice versa. Each chapter adds another piece to the puzzle. Once we finish the book, a complete picture of Hazardous Waste Operations will be seen.

What is site control? The purpose of site control is to minimize potential contamination of workers, protect the general public from the site's chemical and physical hazards, facilitate work activities, and avoid vandalism. Site control is especially important in emergency situations to ensure communications, site access, efficient evacuation, as well as response. This chapter describes the basic components of a site control program to control the activities and movements of the workforce and equipment at hazardous waste sites.

Several site control procedures can be implemented to reduce workers' and public exposure to chemical and physical hazards, including:

- Compile a site map.
- Prepare the site.
- Establish work zones.
- Enforce the buddy system.
- Establish and strictly enforce decontamination procedures.
- Establish site security measures.
- Set up communication networks.
- Enforce safe work practices.

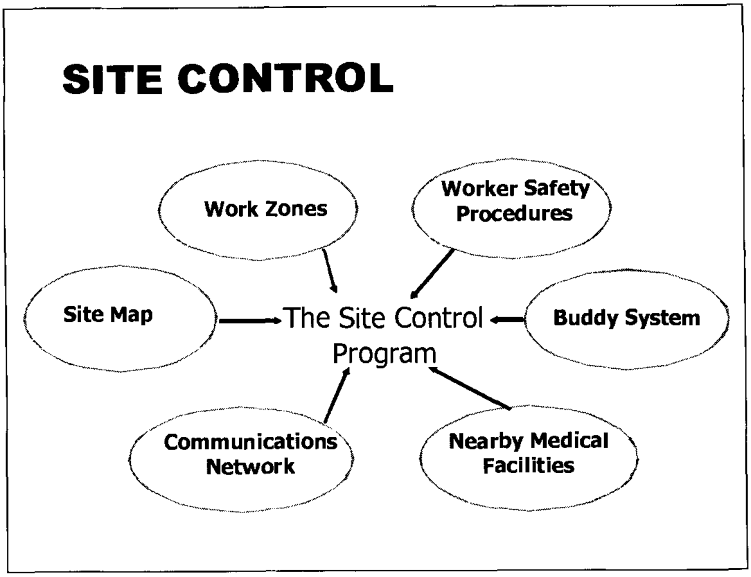


Figure 5.1 These are all pieces of the Site Control puzzle.

The extent of site control necessary depends on site characteristics, site size, and the surrounding community. The appropriate site management will establish the site control program in the planning stages of a project and modify it based on new information and site assessments. He or she will then determine the appropriate sequence for implementing these measures on a site-specific basis. In many cases, it will be necessary to implement several measures simultaneously.

SITE MAP

As a requirement of Hazwoper, a site map must be included as part of the site specific safety plan. This drawing does not have to be anything fancy, and can even be a hand drawn sketch of the area(s) involved in the operations. A site map showing topographic features, predominant wind direction, drainage, and the locations of buildings, containers, impoundments, pits, ponds, and tanks is helpful in:

- Planning activities for current and future operations.
- Assigning personnel to various tasks.
- Identifying access/egress routes, emergency evacuation routes and problem areas.
- Identifying areas of the site that may require the use of personal protective equipment.
- Supplementing the daily safety briefings held in the field.

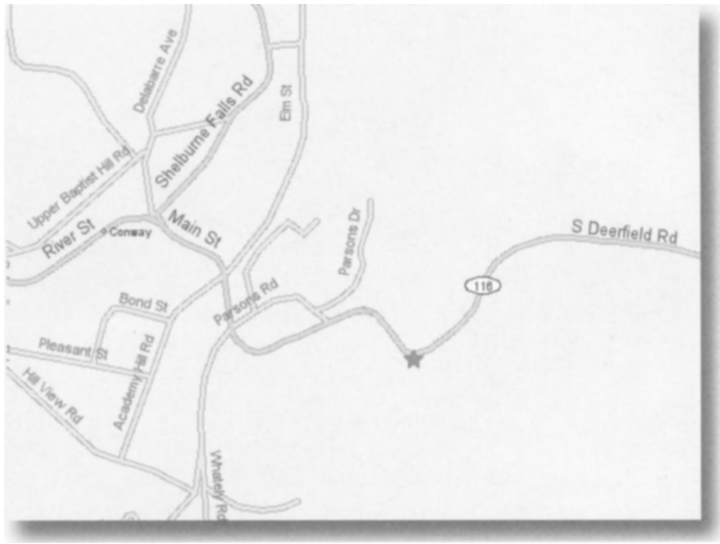


Figure 5.2 A site map shows various roads and areas to be worked.

Typically, the safety officer prepares the map prior to any site entry and updates it throughout the course of site operations to reflect any of the following:

- Accidents
- Changes in site activities.
- Hazards not previously identified.
- New materials introduced on the site.
- Vandalism
- Weather conditions

The use of overlays to help portray information without cluttering the map is beneficial to those who will have the need to use the map. From time to time, the map can get confusing with all of the necessary markings and zone delineations. Keeping it organized will allow it to be more useful.

SITE PREPARATION

A great deal of time and effort is be spent in preparing a site for the clean-up activities and in eliminating obvious physical hazards to ensure that response operations go smoothly and that worker safety is protected. Site preparation should meet the needs of the work plan. Sometimes, site preparation is more hazardous than the actual remediation efforts! This is because we are dealing with the potential for

Figure 5.3 This site includes demolition of some of the structures, as they were heavily contaminated.

building of roadways, construction or demolition of buildings, grading or excavating using heavy equipment, and similar type tasks.

Site Preparation Tasks

Some of the activities that take place during the site preparation include the following:

- Construct roadways to provide ease of access and a sound roadbed for heavy equipment and vehicles
- Arrange traffic flow patterns to facilitate efficient operations
- Eliminate physical hazards from the work area, as much as possible, including those items identified in Table 5.1.
- Install skid-resistant strips on slippery surfaces.
- Construct loading docks, processing and staging areas, and decontamination pads.
- Provide adequate illumination for work activities. Equip temporary lights with guards to prevent accidental contact, and heavy duty electric cords with connections and insulation maintained in good condition. Portable electric lighting shall always be operated at a maximum of 12 volts.
- Ground temporary wiring in accordance with the National Electric Code (NEC). Sheathe or otherwise protect all wiring. Whenever possible, make any

necessary open wiring inaccessible to unauthorized personnel. Splices shall have insulation equal to that of the cable.

Table 5.1 Elimination of Physical Hazards

- exposed or underground electrical wiring, low overhead wiring that may entangle equipment
- sharp or protruding edges, such as glass, nails, and torn metal, which can puncture protective clothing and equipment and inflict puncture wounds
- debris, holes, loose steps or flooring, protruding objects, slippery surfaces, or unsecured railings, which can cause falls, slips, and trips
- ignition sources in flammable hazard area
- unsecured objects, such as bricks and gas cylinders, near the edges of elevated surfaces, such as catwalks, roof tops, and scaffolding, which can dislodge and fall on workers
- debris and weeds that obstruct visibility

SITE WORK ZONES

To reduce the accidental spread of hazardous substances by workers from the contaminated area to the clean area, delineate zones on the site where different types of operations will occur, and control the flow of personnel among the zones. The establishment of work zones will help to assure that personnel are properly protected

Figure 5.4 Skid resistant strips are placed in this area to prevent workers from slip, trip and fall injuries.

Figure 5.5 Materials are stored in a staging area awaiting dispersal by the logistics section.

Figure 5.6 Night operations require sufficient lighting for safety of personnel.

against the hazards present where they are working; confine work activities to the appropriate areas, and help locate and evacuate personnel in the event of an emergency situation. The enforcement of good housekeeping practices in all areas will assist the work force in maintaining the site in a safe and clean condition. Although housekeeping seems like a relatively minor task, it only takes a short time before it can become an overwhelming operation. Supervisors should stress the importance of an orderly workplace to the overall safety picture.

Uncontrolled hazardous waste sites are generally divided into three work zones. Figure 5.1 shows a diagram of these zones. The three zones are: the Exclusion Zone or HOT Zone (the contaminated area), Contamination Reduction Zone or the WARM Zone (the area where decontamination and staging of equipment takes place), and the Support Zone or the COLD Zone (the uncontaminated area where workers should not be exposed to hazardous substances).

Delineation of these three zones should be based on sampling and monitoring results, as well as on an evaluation of potential routes of escape and the amount of contaminant dispersion in the event of a release of the contaminant. Movement of personnel and equipment should be limited among these zones through specific Access Control Points to prevent cross-contamination from contaminated areas to clean areas. (The zones need to be large enough to facilitate the work that needs to be accomplished, but not so large that workers spread contamination over the entire work site.)

Figure 5.7 The orange fence outlines the hot zone line.

Exclusion or Hot Zone

The Exclusion Zone or Hot Zone is the area where contamination does or could occur. Most of the major work activities take place in this area. The primary activities that are performed in the Exclusion Zone are:

- Site characterization, such as mapping, photographing, and sampling of air, water, soil
- Well installation for groundwater monitoring
- Cleanup work, such as drum movement, drum staging and material bulking
- Remediation efforts and cleanup activities
- Treatment activities related to soil or incineration at the site

Project Supervisors need to establish the outer boundaries of the Exclusion Zone, called the Hotline, according to the criteria listed in Table 5.2. It should be clearly marked by lines, cones, hazard (caution) tape and/or signs, or the zone should be enclosed by physical barriers, such as chains, fencing materials, or ropes. Establish Access Points at the periphery of the Exclusion Zone to regulate the flow of personnel and equipment into and out of the zone and to help verify that proper procedures for entering the exiting are followed. If feasible, establish four Access Control Points. Separate entrances for personnel and equipment into the Exclusion Zone, and separate exits for personnel and equipment should be considered, if possible.

The Exclusion Zone can be subdivided into different areas of contamination based on the known or expected type and degree of hazard or on the incompatibility of waste streams. This allows more flexibility in operations, decontamination procedures, and resources.

Figure 5.8 This photo shows a soil incinerator.

The personnel requirements in the Exclusion Zone may include the Field Team Leader, the work parties, and specialized personnel such as heavy equipment operators, sampling technicians, truck drivers, drilling specialists, etc. All personnel within the Exclusion Zone are required to wear the level of protection described in the site specific health and safety plan. There are no exceptions to this. Within the zone, different levels of protection may be justified based on the degree of hazard present; however, this must be specified in the safety plan. In each sub-area, the level of personal protective equipment required by workers in that particular area, needs to be specified.

The required level of protection in the Exclusion Zone varies according to job assignment and the contaminants involved in the project. For example, a worker who collects samples from open containers might require Level B protection, while one that performs walk-through ambient air monitoring might only need Level C Protection. When appropriate, Project Team Leaders should consider assigning different levels of protection within the Exclusion Zone to promote a more flexible, effective, and less costly operation, while still maintaining a high degree of safety.

Table 5.2 Establish the Hotline

1. Visually survey the immediate hazards of the site.
2. Determine the locations of:
   - hazardous substances
   - drainage, leachate, and spilled material
   - visible discolorations
3. Evaluate data from the initial site survey indicating the presence of:
   - combustible gases
   - organic and inorganic gases, particulates, or vapors
   - ionizing radiation.
4. Evaluate the results of soil, air and water sampling.
5. Consider the distances needed to prevent an explosion or fire from the affecting personnel outside the Exclusion Zone.
6. Consider the distances that personnel must travel to and from the Exclusion Zone.
7. Consider the physical area necessary for site operations.
8. Consider meteorological conditions and the potential for contaminants to be blown from the area.
9. Secure and clearly mark the Hotline.
10. Modify the zone location, if necessary, as more information becomes available.

Contamination Reduction or Warm Zone

The Contamination Reduction Zone (CRZ) or Warm Zone is the transition area between the contaminated area and the clean area. This zone is designed to reduce the probability that the clean Support (Cold) Zone will become contaminated or affected by other site hazards. The distance between the Exclusion and Support Zones, combined with decontamination, will limit the physical transfer of hazardous substances to workers and equipment.

Decontamination procedures begin at the boundary between the Exclusion Zone and the Contamination Reduction Zone, called the Hotline. Set up at least two lines of decontamination stations—one for personnel and one for heavy equipment. A large operation may require more than two lines, but usually two is sufficient. Access in and out of the Contamination Reduction Zone from the Exclusion Zone is through Access Control Points; one each for personnel and equipment entrance, one each for personnel and equipment exit, if feasible. Space and site layout are considerations that will be used to determine feasibility.

The degree of contamination in the Contamination Reduction Zone decreases as one moves from the Hotline to the Support Zone, due both to the distance and the decontamination procedures.

The boundary between the Support Zone and the Contamination Reduction Zone, called the Contamination Control Line, separates the possibly low contamination area from the clean Support Zone. Access to the Contamination Reduction Zone from the Support Zone is through two Access Control Points if personnel entering the Contamination Reduction Zone wear the personal protective clothing and equipment prescribed for working in the Contamination Reduction Zone. To re-enter the Support Zone, workers are required to remove any personal protective equipment and leave any tools or equipment used in the Contamination Reduction Zone, and leave through the personnel exit Access Control Point.

The personnel stationed in the Contamination Reduction Zone are usually the Site Safety Officer, a Personnel Decontamination Station (PDS) Operator, and any emergency response personnel that may be assigned to the operation. Additional personnel may assist the PDS Operator by operating a mini-decontamination system for samples taken in the Hot Zone.

The Contamination Reduction Zone must be well laid out to facilitate the following:

- Decontamination of equipment, including all heavy equipment and vehicles, PDS operators, personnel and samples
- Emergency Response: transport for injured personnel (safety ropes, stretcher); first-aid equipment (such as bandages, blankets, eye wash, splints, and water); containment equipment (absorbent materials, fire extinguisher, booming materials, etc.)
- Equipment Re-supply: supplied air tank changes, personal protective clothing and equipment (such as booties and gloves), sample equipment (such as approved bottles, labels, and glass rods), and tools
- Worker Temporary Rest Area: Toilet facilities, bench, chair, liquids, and shade. Water and other fluid replacement drinks should be clearly marked and stored properly to ensure that all glasses and cups are clean. (Consider use of individ-

Figure 5.9 Portable toilet facilities are in the staging area awaiting placement in the field.

ual bottled water and electrolyte replacement drinks, as this cuts down on the trash accumulation of cups, and lessens the threat of someone drinking from a contaminated container.) Hand washing facilities should be located near drinking facilities to allow employees to wash before drinking. Drinking, washing, and toilet facilities should be located in a safe area where protective clothing can be removed. Inspect and clean facilities regularly to avoid housekeeping issues and contamination spread.

- Drainage of water and other liquids that are used in the decontamination process.

Project Team Leaders and other supervisory personnel should think about requiring personnel within the Contamination Reduction Zone to maintain internal communications, line-of-sight contact with work parties, work party monitoring (breathing air time left, fatigue factor, heat stress, hypothermia, etc.), and site security, in an effort to keep everyone safe.

Support Zone or Cold Zone

The Support Zone is the location of the administrative and other support functions needed to keep the operations in the Exclusion and Contamination Reduction Zones running smoothly and efficiently. The personnel present in the Support Zone depend on the functions being performed. At a minimum, there is the Command Post Supervisor. Others may include the Project Team Leader and field team members who are preparing to enter who have returned from the Exclusion Zone.

Personnel may wear normal work clothing within this zone. There are some exceptions to this and Table 5.3 describes normal work clothing exceptions. Potentially contaminated clothing, equipment, and samples must remain in the Contamination Reduction Zone until they are decontaminated or otherwise disposed of as hazardous waste. It is the responsibility of Support Zone personnel to alert the proper agency(s) in the event of an emergency on site. All emergency telephone numbers, evacuation route maps, and vehicle keys are kept in the Support Zone. This is so, in the event of an emergency, the important information/items are in the Cold Zone, and are readily available for retrieval by authorized personnel.

Support facilities, as listed in Table 5.4 are located in the Support Zone. To site these facilities, consider factors such as:

- Accessibility: Topography; open space available; locations of highways or roads; railroad tracks; ease of access for emergency vehicles.
- Resources: Adequate roads, power lines, telephone, shelter, and water.
- Visibility: Line-of-sight to all activities in the Exclusion Zone.
- Wind Direction: Upwind of the Exclusion Zone, if possible.

Table 5.3 Normal Work Clothing Exceptions

- No sneakers or tennis shoes
- No open toe or high heel shoes
- No tanks tops
- No shorts
- No sandals or flip flops
- No bathing suits

BUDDY SYSTEM

The buddy system is a requirement of the Hazwoper regulation and is a critical component of the site control program. Enforcement of the buddy system is everyone's responsibility, just as safety is everyone's responsibility. Why do we need this system? It prevents having workers from entering hazardous areas alone. Additionally the buddy system provides the following benefits:

- Provides each person with assistance.
- Allows for each person to observe for signs of heat or chemical exposure.

Table 5.4 Support Zone Activities

SUPPORT ZONE ACTIVITIES	
Facility	**Function**
Command Post	Supervision of all field operations and field team personnel.
	Maintenance of communications, including emergency lines of communication. • Record keeping, including: • accident reports • chain-of-custody records • daily logbooks • manifest directories and orders • medical records • personnel training records • site inventories • site safety map • up-to-date safety manuals/programs/procedures • up-to-date site safety plans
	Interfacing with the public: government agencies, local politicians, medical personnel, the media, and other interested parties.
	Monitoring work schedules and weather/tide changes.
	Maintenance of site security operations/plan.
	Sanitary facilities (toilets and hand washing facilities)
Medical Station	First-aid administration
	Medical emergency response
	Medical monitoring activities
	Sanitary facilities
Equipment and Centers	Supply, maintenance, and repair of communications, respiratory, and sampling equipment
	Maintenance and repair of vehicles, tools and portable equipment
	Replacement of expendable supplies
	Storage of monitoring equipment and supplies. Storage may be here or in an on-site field laboratory
Administration	Sample shipment
	Interface with home office and/or client/contractors
	Maintain emergency telephone numbers, evacuation route maps, and vehicle keys
	Coordination with transporters, disposal sites, and appropriate Federal, State and Local regulatory agencies

(continues)

Table 5.4 Support Zone Activities *(continued)*

SUPPORT ZONE ACTIVITIES	
Facility	**Function**
Field Laboratory	Coordination and processing of environmental and hazardous samples
	Packaging of materials for analysis following the decontamination of the outside of the sample containers. This packaging can also be done in a designated location in the Contamination Reduction Zone. Keep shipping papers and chain-of-custody files in the Command Post Office.
	Have copies of the sampling plans and procedures available for quick references in the laboratory.
	Maintain and store laboratory notebooks in designated locations in the laboratory while in use. Keep notebooks in the Command Post Office when not in use.

- Allows partners to periodically check for integrity of the personal protective equipment.
- Allows for notification of site supervisor/emergency officials in the event of an emergency on site.

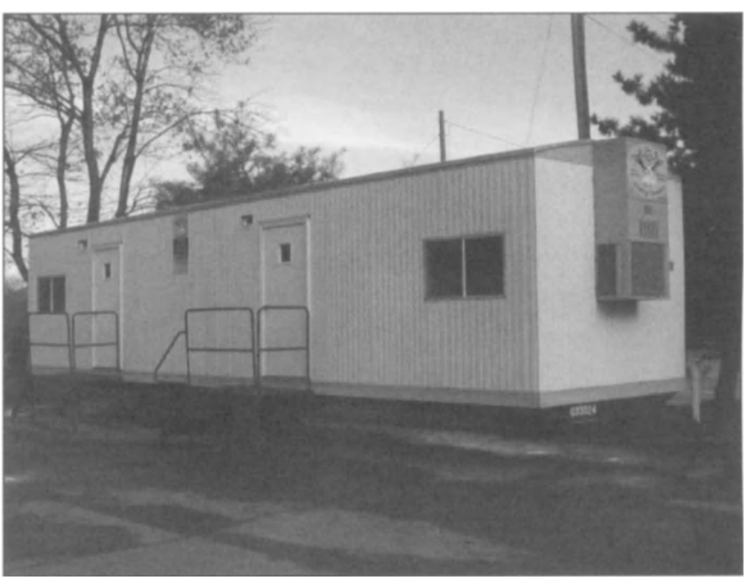


Figure 5.10 This office trailer is the place in the support zone where administrative functions are completed.

This system doesn't mean that employees need to enter work zones holding hands or hanging on to their partner! It does mean that workers should be able to rely on the fact that another worker or workers are nearby and available to assist one another, not only for emergencies, but for routine tasks that may require more than one person to complete.

ENFORCE DECONTAMINATION PROCEDURES

Decontamination procedures are detailed in writing, in the site safety plan for the project. The goal of decontamination is prevent the spread of contamination, as well as to protect the environment and the general public.

We put the procedures in writing so that everyone involved is aware of the proper method for cleaning personnel, tools, and equipment which has become contaminated. Someone (usually the Safety Officer) needs to be responsible for ensuring that the decontamination efforts are to be carried out correctly.

Lack of proper decontamination can be one of the most costly items that a company has to deal with. By tracking contaminants from the site, companies are responsible for the cleanup costs. Also, it is not a good policy to allow workers to leave a contaminated waste site without having gone through decontamination. Workers then carry those contaminants in their cars or company vehicles to the office, shop, or worse-their homes. At this point, co-workers, family and the general public are all

Figure 5.11 The buddy system at work!

being unnecessarily exposed to hazardous substances and they don't even know it. We need to keep in mind here, that many of the materials we deal with may be clear or odorless. When a worker tracks oil off the site, it is relatively easy to spot. For these reasons, proper decontamination must be strictly enforced.

SECURITY MEASURES

As the chapter title (Site Control) indicates, we need to be very concerned about securing the work site from a number of perspectives. The general public should be prohibited from entering a hazardous waste work area to prevent them from becoming contaminated and the potential for further spread of the contamination.

This can be done in a variety of ways. Some of the more common ways include the following:

- Caution Tape
- Fencing materials
- Signage
- Security guards, police officers, watch persons

As a result of the types of work we are performing at hazardous waste sites, very expensive pieces of equipment, both small and large, are utilized. These range from instrumentation for air monitoring and calibration to excavators and other heavy equipment. Quite often this equipment is a target for theft and or vandalism.

Heavy equipment theft is a growing problem in our country. The National Crime Information Center (NCIC) in 2001 had approximately 5,500 heavy equipment thefts reported. Although there is no single place where heavy equipment loss is recorded, some national surveys estimate the total value of equipment stolen annually ranges between $300 million and $1 billion.

Heavy equipment is mobile off-road equipment that may be either self-propelled or towed. This equipment is stolen because it is often unsecured, it is valuable, and it's easy to sell. In comparison to the car theft recovery rate of about 62%, only about 10 to 15% of stolen heavy equipment is recovered. Many equipment owners estimate that their equipment is stolen on a Friday evening and not discovered until Monday morning. In cases of heavy equipment owners with large fleets or multiple sites, the theft might not be discovered for even longer periods of time.

Ensure good perimeter security by:

- Installing see-through perimeter fencing and keeping it well maintained
- Using barriers that prevent a piece of equipment from being driven or towed off, in addition to fencing
- Posting the site with "Warning" and "No Trespassing" signs
- Using high security locks on heavy duty gates

Figure 5.12 Security detail directs traffic at the site and checks for authorization for access to site areas.

- Limiting key access for fenced areas
- Limiting the number of entrances and exits at sites
- Installing and maintaining lighting

Other actions that will add to site control include the following:

- Not leaving equipment on trailers when unattended
- Maintaining a log of all equipment serial or product identification
- Installing a system that disables equipment's electrical or ignition systems if universal keys are used
- Using anchoring or immobilizing techniques like chains, cables, removing batteries, etc.
- Installing a tracking transmitter in each unit

Buildings, trailers, job boxes, and other places for storage of equipment should be locked and secured so that unauthorized personnel cannot gain access to the area. Roving security patrols, increased surveillance by local police or cameras, and periodic checking by site management will all assist in securing site equipment, tools, vehicles, and heavy machinery.

Figure 5.13 This sign is posted at the entrance to a hazardous waste site.

Figure 5.14 Heavy equipment is shown off the trailers. This deters thieves to some extent.

COMMUNICATION NETWORKS

When we think of communication networks, most of us automatically think high technology. While high technology is certainly an option available for us to use, we may also use simple communication devices, as well. As far as communications go, we should divide this area into internal and external communications.

Internal Communications

Internal communications include the use of telephones and radio systems to communicate. It also includes hand signals, warning devices, bells, sirens, whistles, etc. Some issues you should think about when dealing with internal communications include the following:

- Ensure adequate radio or telephone coverage
- If using cell phones, make sure you have charging capabilities (auto adapter and household plug) and/or spare batteries.
- Test the warning devices periodically to see if they work (don't wait for an emergency to find out they are not functioning properly).
- Consider banning the use of cellular phones with cameras, as many sites do not allow them on the property for security reasons.

- Use caution when using the vibrate mode on cell phones and pagers. If workers are not used to that particular mode, the sudden vibration may startle them and may cause the worker to get seriously injured and/or interrupt the work process.

Figure 5.15 This unit allows supervisors to track a piece of heavy equipment if stolen.

Safety Meetings

One last item associated with internal communications is probably the most important. That is having daily safety meetings. Please don't get excited or panic when you read this statement. I mean what I say about daily safety meetings. They are extremely important. They don't have to be budget breakers, however. Many supervisors tell me that it is impossible to do every day. I don't think it is impossible. In my opinion, there is not a company out there that cannot afford to have a daily safety meeting!

Having a safety meeting does not mean that we need to have a PowerPoint presentation or use a video tape every day. Those types of presentations have their place. What I am referring to is a "tailgate" or "toolbox" safety meeting. They are brief meetings to cover a few topics and can be done in a few minutes, while getting the important points out to the work force. Most times this can be done in less than five minutes. Now, tell me that you don't have the time to have a safety meeting every day! I'll bet you have time for a coffee break every day. Why not combine them? You may find that you'll get more accomplished in a safe manner by doing so.

External Communications

External communications are every bit as important as internal communications. Meeting with customers, clients, contractors, and subcontractors are part of the external communications system. Keeping the customer happy is one of the top priorities. However, with several contractors and subcontractors involved, this is a difficult task. You will also be expected to converse with representatives of the regulatory agencies that may have jurisdiction or oversight on the project. This could involve face-to-face meetings, telephone or conference calls, letters, emails, etc.

Figure 5.16 This camera on the pole video tapes activities in the area and also acts as a theft deterrent.

Project managers and other members of the workforce will likely have the opportunity to interact with emergency response officials. This may take place as a routine visit, an inspection, or an actual emergency incident. It would be extremely helpful for both parties to have already established a relationship.

SUMMARY

As was mentioned earlier, site control encompasses a great many items, all of which are important to the safe operations at hazardous waste sites. None of these items can be discounted, as each is critical to the proper cleanup and remediation efforts at these sites. I ask that you carefully review each of the key components listed under site control whenever you are dealing with a site, no matter the size. By themselves, they seem insignificant, however, they all are pieces to an integral puzzle that need to fit together in order to make the operation safe and successful.

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE MANUAL
by Brian J. Gallant

6

TOXICOLOGY AND MEDICAL MONITORING

Toxicology is defined as the study of chemical or physical agents that interact with biologic systems to provide a response in organisms. It is not my intention to make any of you toxicologists by reading this chapter! However, we are dealing with hazardous materials and hazardous waste, and we should have an understanding of what toxicology is and how it affects each of us. "My" definition of toxicology is: *the effect that certain substances have on the human body*. We need to remember that each of us is different and, as a result, the substance we are exposed to may have a different effect on each of us. For example, are you allergic to anything? Food? Animals? Grass or pollen? Medicine? If you are, then that is an example of toxicology. Personally, I am allergic to cats. In my case, I get an itchy throat, watery eyes, and some difficulty in breathing.

Toxicity is the relative ability of a substance to cause injury to biologic tissue. Given the broad range of toxicities any substance might eventually evoke in an organism, it is easy to understand the wisdom of Paracelsus (1493–1541) when he said, "All substances are poisons, there is none which is not a poison. The right dose differentiates a poison and a remedy."

The dose or amount of a substance given to an organism influences whether the effects are toxic, nontoxic, or beneficial. In toxicological studies, the dose given to test animals is expressed in terms of quantity administered:

- Per unit weight, usually expressed as milligrams of substance per kilogram of body mass (mg/kg), or part per million (ppm)
- Per unit weight expressed as micrograms of a substance per kilogram of body mass (ug/kg) or part per billion (ppb)

- Per area of skin surface, expressed as mg/cm^2
- Per unit volume of air inhaled, usually expressed as parts of a vapor or gas per million parts of air by volume (ppmv) (Air results can also be expressed as milligrams of material per cubic meter of air (mg/m^3). Inhaled doses can also be expressed by time.)

TOXICITY VS. HAZARD

The toxicity of a material is not synonymous with its health hazard. Toxicity is the capacity of a material to produce injury or harm. Hazard is the possibility that exposure to a material will cause injury when a specific quantity is used under certain conditions.

Some of the key elements to be considered when evaluating a material as a health hazard are:

- How much of the material is required to be in contact with a body cell and for how long to produce injury?
- What is the probability that the material will be absorbed or come in contact with body cells?
- What is the rate of generation of airborne contaminants?
- What control measures are in use or will be used?

The effects of exposure to a substance are dependent on dose, rate, physical state of the substance, temperature, site of absorption, diet, and general state of health of the individual.

TOXICITY TESTS

The design of any toxicity test incorporates selection of:

- A test organism, which can range from cellular material and selected strains of bacteria to higher-order plants and animals
- The response or biological endpoint, which can range from subtle changes in physiology and behavior to death
- An exposure or test period
- A dose or series of doses

The objective is to select a test species that is a good model of humans, a response that is not subjective and can be consistently determined, and a test period that is relatively short. Often tests must be selected that yield indirect measurements or responses that supposedly correlate with the response of interest—for example, determining carcinogenic potential by measuring mutagenic potential.

Dose-Response Relationship

A particular toxicity test exhibits a dose-response relationship when there is a consistent mathematical and biologically plausible relationship between the proportion of individuals responding and a given dose for a given exposure period: for example, the numbers of mortalities increase as the dose of a chemical given to a group of organisms increases.

Measurement of Response

Different species of test organisms differ in how they respond to a specific chemical. In addition, there are variations in response to a given dose within a group of test organisms of the same species. Typically, this intraspecies variation follows a normal (Gaussian) distribution when the number of organisms responding is plotted against the degree of response for a given dose.

Thus, a relatively small number of experimental groups can be tested and statistical techniques can be used to define the probable response of the average organisms to a given dose. Graphically, this average response is depicted as a point, with bars used to exhibit one standard deviation above and below the average. Typically, frequency-response curves are not used. Instead, cumulative dose responses are utilized, which depict the summation of the frequency-response curves over the range of doses. A further refinement can be made by plotting the cumulative response against the logarithm of the dose, which yields plots that are generally linear. Several basic relationships can be readily identified from the plots. A dose is often described as either a lethal dose (LD) in a test where the response is mortality or effective dose (ED) in a test where the response is some other observable effect.

Constructing a dose-response curve enables the identification of doses that affect a given percent of the exposed population, e.g., the LD_{50} is that dose which is lethal to 50 percent of the test organisms.

Dose-Response Terms

The National Institute for Occupational Safety and Health (NIOSH) defines a number of dose-response terms (Table 6.1) in the *Registry of Toxic Substances*.

- Toxic Dose Low (TD_{lo}): The lowest dose of a substance introduced by any route, other than inhalation, over any given period of time and reported to produce any toxic effect in humans or to produce or reproductive effects in animals
- Toxic Concentration Low (TC_{lo}): The lowest concentration of a substance in air to which humans or animals have been exposed for any given period of time

that has produced any toxic effect in humans or tumors or reproductive effects in animals

- Lethal Dose Low (DL_{lo}): The lowest dose, other than LD_{lo}, of a substance introduced by any route other than inhalation that has been reported to have caused death in humans or animals
- Lethal Dose Fifty (LD_{50}): A calculated dose of a substance that is expected to cause the death of 50 percent of an entire defined experimental animal populations determined from the exposure to the substance by any route other than inhalation
- Lethal Concentration Low (LC_{lo}): The lowest concentration of a substance in air, other than $LC_{50,}$ that has been reported to have caused death in humans or animals
- Lethal Concentration Fifty (LC_{50}): A calculated concentration of a substance in air, exposure to which for a specified length of time is expected to cause the death of 50 percent of an entire defined experimental animal population

Table 6.1 Dose-Response Terms

Category	Exposure Time	Route of Exposure	Human	Animal
TD_{Lo}	Acute or chronic	All except inhalation	Any non-lethal	Reproductive, tumors
TC_{Lo}	Acute or chronic	Inhalation	Any non-lethal	Reproductive, tumors
LD_{Lo}	Acute or chronic	All except inhalation	Death	Death
LD_{50}	Acute	All except inhalation	Not Applicable	Death statistically determined
LC_{Lo}	Acute or Chronic	Inhalation	Death	Death
LC_{50}	Acute	Inhalation	Not Applicable	Death statistically determined

Use of Dose-Response Relationship

Comparing the LD_{50} of chemicals in animals gives a relative ranking of potency or toxicity. For example, DDT (LD_{50} for rats = 113 mg/kg) would be considered more toxic than ethyl alcohol (LD50 for rats = 1,400 mg/kg). Using this LD_{50} (mg/kg) and multiplying by 70 kg (average mass of man) gives a rough estimate of the toxic potentials of the substances for humans, assuming that humans are as sensitive to the substances as the species tested. Since the extrapolation of human data from animal stud-

Table 6.2 Combined Tabulation of Toxicity Classes

Commonly Used Terms	LD_{50} Single Oral Dose for Rats (g/kg)	4-hour Vapor Exposure Causing 2 to 4 Deaths in 6-rat Groups (ppm)	LD_{50} Skin for Rabbits (g/kg)	Probable Lethal Dose for Man
Extremely Toxic	0.001 or less	Less than 10	0.005 or less	Taste (1 grain)
Highly Toxic	0.001 to 0.05	10 to 100	0.005 to 0.043	1 tsp. (4 cc)
Moderately Toxic	0.05 to 0.5	100 to 1,000	0.044 to 0.340	1 oz. (30 gm)
Slightly Toxic	0.5 to 5.0	1,000 to 10,000	0.35 to 2.81	1 pint (250 gm)
Practically Non-Toxic	5.0 to 15.0	10,000 to 100,000	2.82 to 22.6	1 quart
Relatively Harmless	> 15.00	> 100,000	> 22.6	> 1 quart

ies is very difficult, this value should only be considered as an approximation for the potency of the compound and used in conjunction with additional data (Table 6.2).

Limitations of Dose-Response Data

Several limitations must be recognized when using dose-response data. First, a LD_{50} is a single value and does not indicate the toxic effects that may occur at different dose levels. For example, in Table 6.3, Chemical A is assumed to be more toxic than Chemical B based on LD_{50}, but at lower doses the situation is reversed. At LD_{20} Chemical B is more toxic than Chemical A.

Second, most LD_{50} data are derived from acute (single-dose, short-term) exposures rather than a chronic (continuous, long-term) exposure. Data cannot be extrapolated if the disposition of the chemical (that is; bioaccumulation, metabolism, excretion) or the target organ is not known. For example, carcinogens are usually more toxic if the dose is administered over several exposures instead of one single exposure.

A third shortcoming is that usually there is little information to guide the choice of the animal data that mimic human exposure. Are humans less or more sensitive than the test species? For example, in human studies arsenic is a carcinogen; in animal studies it is not.

For chronic human exposure, one guide is to extrapolate chronic animal data that gives a no-effect dose. Usually this dose is not found in the literature, and thus, the dose-response curve is needed. The most appropriate human data is usually obtained through epidemiological studies when available.

Many factors affect the normal dose-response relationship and should be considered when extrapolating toxicity data to a specific situation (See Table 6.3).

Figure 6.1 Here a nurse practitioner examines a worker.

Table 6.3 Classification of Factors Influencing Toxicity

Type	Examples
Factors related to the chemical	Composition (salt, tree base, etc.); physical characteristics (particle size, liquid, solid, etc.); physical properties (volatility, solubility, etc.); presence of impurities; breakdown products; carrier.
Factors related to exposure	Dose; concentration; route of exposure (indigestion, skin absorption, injection, inhalation); duration.
Factors related to person exposed	Heredity; immunology; nutrition; hormones; age; sex; health status; pre-existing diseases
Factors related to environment	Carrier (air, water food, soil); additional chemicals present (synergism, antagonisms); temperature; air pressure.

ROUTES OF EXPOSURE

The route by which a substance enters the body determines how much is absorbed and which organs are exposed to the highest concentration. For example, the amount of chemical that is toxic orally may not be as toxic when applied to the skin. The four routes of exposure are:

- Ingestion
- Injection
- Inhalation
- Skin contact or absorption

Gender Differences

Some substances may be more toxic to one gender than the other. For example, women have a larger percent of body fat, which means that they can accumulate more fat-soluble substances than men. Women also have different susceptibilities to teratogenic chemicals. There is evidence that some cancers and other diseases are sex-linked as well.

Age

The saying "You're not as young as you used to be" certainly plays an important role in toxicology. Older people have different blood and hepatic systems, musculature, metabolism, and excretory patterns than younger people, which change the disposition and toxic effects of chemicals. Also, children are not small adults. For example, they have higher respiration rates, different susceptibilities (less sensitive to stimulants of the central nervous system but more sensitive to depressants), metabolism, and excretory patterns. The elderly and the very young are more apt to pick up diseases and are often prone to viruses and the like.

Synergism, Antagonism, and Potentiation

Some combinations of chemicals produce different effects than those attributed to each individually:

- Synergists are chemicals that, when combined, cause a greater additive effect:for example, hepatotoxicity is enhanced as a result of exposure to both ethanol and carbon tetrachloride.
- Potentiation is a type of synergism where the potentiator is not usually toxic in itself but has the ability to increase the toxicity of other chemicals: isopropanol, for example, is not hepatotoxic in itself but in combination with carbon tetrachloride, it increases the toxic response
- Antagonists are chemicals, that when combined, lessen the predicted effect; there are four types of antagonists:
    - Functional: produces opposite effects on the same physiologic function—for example, phosphate reduces lead absorption.
    - Chemical: reacts with the toxic compound to form a less toxic product—for example, collating agents bind up metals such as lead, arsenic and mercury.
    - Dispositional: alters absorption, metabolism, distribution, or excretion—for example, some alcohols use the same enzymes in their metabolism.

      Ethanol ≡ acetaldehyde ≡ acetic acid
      Methanol ≡ formaldehyde ≡ formic acid

      The aldehydes cause toxic effects (hangover blindness). Ethanol is more readily metabolized than methanol, so when both are present, the latter is not metabolized and can be excreted before forming formaldehyde. Another dispositional antagonist is Antabuse, which, when administered to alcoholics, inhibits the metabolism of acetaldehyde, giving the patient a more severe and prolonged hangover.
    - Receptor: occurs when a second chemical either binds to the same tissue receptor as the toxic chemical or blocks the action of a receptor and thereby reduces the toxic effect—for example, atropine interferes with the receptor responsible for the toxic effects of organophosphate pesticides

Genetics

People are not born genetically equal. Some lack genes that produce enzymes that can alter the toxicities of some chemicals. For example, when people with a certain enzyme deficiency are given aspirin or certain antibiotics, they are more likely to suffer damage to their red blood cells than persons with the normal form of the same enzyme.

Species Variation

The physiological differences among various animal species lead to the "Catch 22" of toxicology. Animals are used as models to study the mechanisms of toxicity of chemicals; therefore, the proper selection of test animals requires knowing which most closely resemble humans with respect to the chemical of interest. The goal of animal studies is to predict chemical effects on humans. However, selecting the appropriate animal requires knowledge of the fate of the chemical in humans (the goal) as well as its fate in various animals.

Kinds of Toxicity

There are several kinds of toxicity:

- Acute: effects noted in a test species 24 to 72 hours following exposure to the toxicant; the effects may be as serious as death or as temporary as drunkenness (dizzy, loss of equilibrium)
- Chronic: effects of exposure to a chemical that manifest themselves several weeks, several months, or several years after exposure (which may have been isolated or repeated daily for many years)
- Local: action of a toxic substance on the specific area of contact; often this refers to the skin, mucous membranes, eyes or throat; the toxic effect due to the exposure is usually not noted elsewhere in the animal (liver, kidney, etc.)
- Systemic: action of substance that is distributed throughout the body; an example might be the inhalation of chloroform and the resultant effects on the brain, nervous system, liver, and kidney

TYPES OF TOXIC EFFECTS

Workers can be affected two ways. They are:

- Acute
- Chronic

An acute effect is something that typically results from an immediate exposure up to about 72 hours. Some of the more common acute effects include:

- Nausea
- Headache

- Dizziness
- Vomiting
- Itchy throat
- Watery eyes
- Blindness
- Death

You can see that the effects ranged from rather minor ailments to the ultimate — death! Please remember that just because a substance has an acute effect on you, it may be a serious event. For example, an exposure to an oxygen-deficient atmosphere (for a period of time) is likely to cause death (acute effect).

Figure 6.2 Physical examinations are a critical part of a medical surveillance program.

Chronic effects are more long-term. They may not show up for 20 to 30 years or more. The best example of a chronic effect is probably cancer. As most of us realize, exposure to a cancer-causing substance will not necessarily result in cancer. But a diagnosis of cancer will not be forthcoming from a physician the day after the exposure. Some other chronic effects are:

- Emphysema
- Liver damage
- Cirrhosis
- Lung disease

Toxic Substances and Cancer-Causing Agents

A carcinogen can be defined as a substance that will induce a malignant tumor in a person following a reasonable exposure. Another more technical definition is that a carcinogen is a substance that will induce any neoplastic growth in any tissue of any animal at any dose by any method of application applied for as long as the lifetime of the animal. Some key facts include:

- NIOSH estimates that 2,000 chemicals may be carcinogenic.
- Some materials can produce cancer in the lung after inhalation or use the lung as a route of entry and produce the cancer somewhere else

A mutagen is something that affects the genetic system of the exposed people or animals in such a way that it may cause cancer or an undesirable mutation in some later generation.

The term is derived from teratogenesis, which refers to the production of monsters or monstrous growth. A teratogen is a compound that affects the fetus through the mother so that the fetus is either killed in the uterus or born with a significant deformity.

Action at the Site of Contact

Contact with hazardous materials should be avoided to the extent possible. That may be by wearing personal protective equipment or limiting the exposure time for certain materials. The following are some of the common classification of materials we might see at waste sites:

- Irritants—ammonia, amyl acetate, sulfur dioxide, lachrymators
- Corrosives—effects on eyes, esophagus, skin, nasal passages, lung, and stomach
- Hepatotoxins (liver)—chemicals that effect the liver's ability to detoxify contaminants (mostly hydrocarbons and alcohols)
- Nephrotoxins (kidney)—chemicals that adversely alter kidney function (including antibiotics such as, bacitracin, glycols, and mercury)
- Brain toxins—chemicals that alter brain-cell function or slowly impair thought processes—central-nervous-system effects (ethanol and elemental mercury)
- Cardiotoxins (heart)—chemicals that alter heart muscle tissue or its ability to interpret brain commands (cadmium, nickel, cobalt, TCE)
- Neurotoxins (nervous system)—chemicals that destroy the nerve sheath or the axon such that control of the nervous system is impaired (hexane and methyl-N-butyl ketone).
- Ocular toxins—agents that can adversely affect the eye as a result of chronic exposure (hydroquinone and methanol)
- Pulmonary toxins—chemicals that affect the lung; specifically macrophages, Type I and Type II cells, alveoli, and membranes (silica, asbestos, nitrogen dioxide, plutonium, beryllium, acids, etc.)
- Bone toxins—chemical that affect bone growth or strength including,"bone seekers" (radium, phosphorus, and strontium)
- Behavioral toxicants — chemicals that affect memory, temperament, personality, or performance (carbon disulfide, mercury, etc.).

INTRODUCTION TO MEDICAL MONITORING

Workers handling hazardous wastes can experience high levels of stress. Their daily tasks may expose them to toxic chemicals, safety hazards, biologic hazards, and radiation. They may develop heat stress while wearing protective equipment or working under temperature extremes or face life-threatening emergencies such as explosions and fires. Therefore, a medical program is essential to assess and monitor

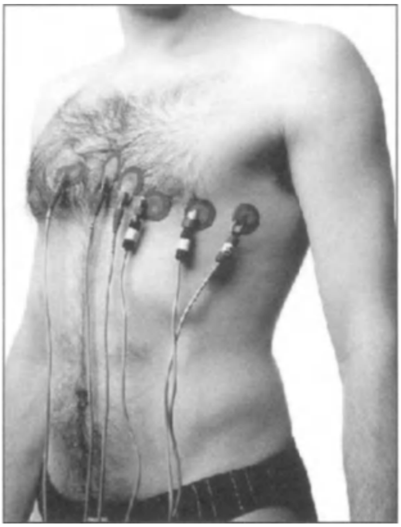


Figure 6.3 Electrocardiograms test a worker's heart and help determine if the person is fit for duty.

workers' health and fitness both prior to employment and during the course of work, to provide emergency and other treatment as needed, and to keep accurate records for future reference. In addition, OSHA recommends a medical evaluation for employees required to wear a respirator (29 CFR Part 1910.134 (b)(10)), and certain OSHA standards include specific medical requirements (e.g., 29 CFR Part 1910.95 and 29 CFR Parts 1910.1001 through 1910.1045). Information from a site medical program may also be used to conduct future epidemiological studies, to adjudicate claims, to provide evidence in litigation, and to report workers' medical conditions to federal, state, and local agencies as required by law.

This section presents general guidelines for designing a medical program for personnel at hazardous-waste sites. It includes information and sample protocols for pre-employment screening and periodic medical examinations, guidelines for emergency and non-emergency treatment, and recom-

Figure 6.4 A healthcare professional administers a pulmonary-function test to a worker. This test will determine the worker's lung capacity and ability to wear respiratory protection.

Figure 6.5 A blood test is taken during a medical surveillance examination.

mendations for program record keeping and review. In addition, it supplies a table of some common chemical toxicants found at hazardous-waste sites with recommended medical monitoring procedures.

The recommendations in this chapter assume that workers will have adequate protection from exposures through administrative and engineering controls and appropriate personal protective equipment and decontamination procedures, as described elsewhere in this manual. Medical surveillance should be used to complement other controls.

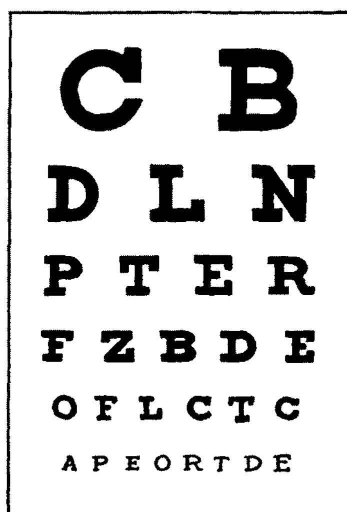


Figure 6.6 An eye chart similar to this one is used in the examination process.

Developing a Program

A medical program should be developed for each site based on the specific needs, location, and potential exposures of employees at the site. The program should be designed by an experienced occupational-health consultant in conjunction with the site safety officer. The director of a site medical program should be a physician who is board-certified in

Figure 6.7 This photo depicts a hearing test booth used in audiograms.

occupational-health services. A director and/or examining physician with such qualifications may be difficult to find, due to the shortage of doctors trained in occupational medicine in remote geographic areas where many hazardous-waste sites are located.

If an occupational-health physician is not available, the site medical program may be managed, and relevant examinations performed, by a local physician with assistance from an occupational-medicine consultant. These functions may also be performed by a qualified registered nurse, preferably an occupational-health nurse, under the direction of a suitably qualified physician who has responsibility for the program.

All medical test analyses should be performed by a laboratory that has demonstrated satisfactory performance in an established interlaboratory testing program. The clinical or diagnostic laboratory to which samples are sent should meet either (1) minimum requirements under the Clinical Laboratories Improvement Act of 1967 (42 CFR Part 74 Subpart M Section 263 (a)) or (2) the conditions for coverage under Medicare. These programs are administered by the Health Care Financing Administration (HCFA), U. S. Department of Health and Human Services (DHHS).

Figure 6.8 A first-aid kit is a handy item at remote hazardous-waste sites. Be sure to restock it after each use.

A site medical program should provide the following components:

- Surveillance:
  - Periodic medical examinations (and follow-up examinations when appropriate)
  - Termination examination (if a previous exam has not been provided in the last six months)
- Treatment:
  - Emergency

  - Non-emergency (on a case—by-case basis)
- Record keeping:
  - Documents kept in secure location
  - Thirty (30)-year retention requirement
- Program review:
  - Annual review
  - Revisions as required

Table 6.4 outlines a recommended medical program; screening and examination protocols are described in the following sections. These recommendations are based on known health risks for hazardous-waste workers, a review of available data on their exposures, and an assessment of several established medical programs. Because conditions and hazards vary considerably at each site, only general guidelines are given.

The effectiveness of a medical program depends on active worker involvement. In addition, management should have a firm commitment to worker health and safety and is encouraged to express this commitment not only by medical surveillance and treatment but also through management directives and informal encouragement of employees to maintain good health through exercise, proper diet, and avoidance of tobacco, alcohol abuse, and drug abuse. In particular, management should:

- Urge prospective employees to provide a complete and detailed occupational and medical history
- Assure employees of confidentiality
- Require workers to report any suspected exposures, regardless of degree

Figure 6.9 Eye wash stations like this are used at sites to flush the eyes of workers who may have had something splashed in them.

Table 6.4 Recommended Medical Program

Component	Recommended	Optional
Pre-Employment Screening	• Medical History • Occupational History • Physical Examination • Determination of fitness to work wearing protective equipment. • Baseline monitoring for specific exposures	• Freezing pre-employment serum specimen for later testing (limited to specific situations, see Baseline Data for Future Exposures in this chapter.)
Periodic Medical Examinations	• Yearly update of medical and occupational history; yearly physcial examination; testing based on (1) examination results, (2) exposures, and (3) job class and task. • More frequent testing based on specific exposure	• Yearly testing with routine medical tests.
Emergency Treatment	• Provide emergency first aid on site. • Develop liaison with local hospital and medical specialists. • Arrange for decontamination of victims. • Arrange in advance for transport of victims. • Transfer medical records; give details or incident and medical history to next care provider.	
Non-Emergency Treatment	Develop mechanism for non-emergency health care.	
Recordkeeping and Review	• Maintain and provide access to medical records in accordance with OSHA and state regulations. • Report and record occupational injuries and illnesses. • Review Site Safety Plan regularly to determine if additional testing is needed. • Review program periodically. Focus on current site hazards, exposures and industrial hygiene standards.	

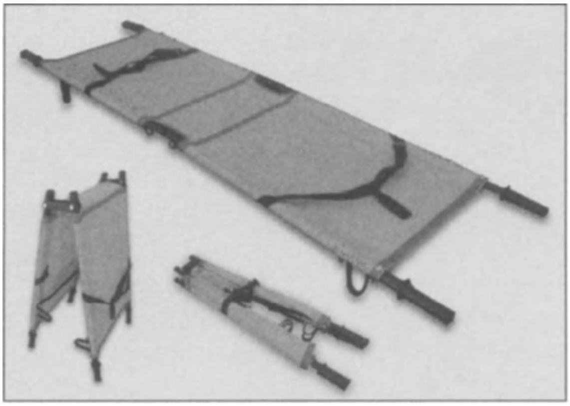


Figure 6.10 A stretcher can assist in transporting an injured worker. If the person cannot be moved, wait for professional medical assistance.

Figure 6.11 Fire blankets are often used at sites.

- Require workers to bring any unusual physical or psychological conditions to the physician's attention; employee training should emphasize that vague disturbances or apparently minor complaints (such as skin irritation or headaches) may be important

When developing an individual program, site conditions must be considered, and the monitoring needs of each worker should be determined based on his or her medical and occupational history as well as current and potential exposures on site. The routine job tasks of each worker should be considered thoroughly. For instance, a heavy-equipment operator exposed to significant noise levels would require a different monitoring protocol from a field sample collector with minimal noise exposure. Likewise, an administrator may only need a pre-employment screening for the ability to wear personal protective equipment—if this is an occasional requirement—rather than a more comprehensive physical examination program.

The potential exposures that may occur at a site must also be considered. While it is nearly impossible to identify every toxic substance that exists at each hazardous-waste site, certain types of hazardous substances or chemicals are more likely to be present than others. Some of these are:

- Aromatic hydrocarbons
- Asbestos (or asbestos particles)
- Dioxins
- Halogenated aliphatic hydrocarbons
- Heavy metals
- Herbicides
- Organochlorine insecticides
- Organophosphate insecticides
- Polychlorinated biphenyls (PCBs)

In compiling a testing protocol, bear in mind that standard occupational medical tests were developed in factories and other enclosed industrial environments and were based on the presence of specific identifiable toxic chemicals and the possibility of a significant degree of exposure. Some of these tests may not be totally appropriate for hazardous-waste sites, since available data suggests that site workers have low-level exposures to many chemicals concurrently plus brief high-level exposure to some chemicals. In addition, most testing recommendations, even those for specific toxic substances, have not been critically evaluated for efficacy.

Pre-Employment Screening

Pre-employment screening has two major functions: (1) determination of an individual's fitness for duty, including the ability to work while wearing protective equipment, and (2) provision of baseline data for comparison with future medical data. These functions are discussed below. In addition, a sample pre-employment examination is described.

Determination of Fitness for Duty

Workers at hazardous-waste sites are often required to perform strenuous tasks (e.g., moving 55-gallon drums) and wear personal protective equipment, such as respirators and chemical protective clothing that may cause heat stress and other problems. To ensure that prospective employees are able to meet work requirements, the pre-employment screening should focus on occupational and medical history, a physical examination, and the ability to wear protective equipment.

Occupational and Medical History

Make sure the worker fills out an occupational and medical-history questionnaire. Review the questionnaire before seeing the worker. In the examining room, discuss the questionnaire with the worker, paying special attention to prior occupational exposures to chemical and physical hazards:

- Review past illnesses and chronic diseases, particularly atopic diseases such as eczema and asthma, lung diseases, and cardiovascular disease.
- Review symptoms, especially shortness of breath or labored breathing on exertion, other chronic respiratory symptoms, chest pain, high blood pressure, and heat intolerance.
- Identify individuals who are vulnerable to particular substances (e.g., someone with a history of severe asthmatic reaction to a specific chemical).
- Record relevant lifestyle habits (e.g., cigarette smoking, alcohol and drug use) and hobbies (running, jogging, etc.)

Physical Examination

Conduct a comprehensive physical examination of all body organs, focusing on the pulmonary, cardiovascular, and musculoskeletal systems:

- Note conditions that could increase susceptibility to heat stroke, such as obesity and lack of physical exercise.
- Note conditions that could affect respirator use, such as missing or arthritic fingers, facial scars, dentures, poor eyesight, or perforated eardrums.

Ability to Work While Wearing Protective Equipment

- Disqualify individuals who are clearly unable to perform based on the medical history and physical exam (e.g., those with severe lung disease, heart disease, or back or orthopedic problems)
- Note any limitations concerning the worker's ability to use protective equipment.
- Provide additional testing (e.g., chest x-ray, pulmonary-function testing, electrocardiogram) for ability to wear protective equipment where necessary.
- Base the determination on the individual worker's profile (e.g., medical history and physical exam, age, previous exposures and testing).
- Make a written assessment of the worker's capacity to perform while wearing a respirator if wearing a respirator is a job requirement. Note that the Occupational Safety and Health Administration's (OSHA) respiratory protection standard (29 CFR Part 1910.134) states that no employee should be assigned to a task that requires the use of a respirator unless it has been determined that the person is physically able to perform the task under such conditions.

Baseline Data for Future Exposures

Pre-employment screening can be used to establish baseline data to subsequently verify the efficacy of protective measures and to later determine if exposures have adversely affected the worker. Baseline testing may include both medical screening tests and biologic monitoring tests. The latter (e.g., blood lead level) may be useful for ascertaining pre-exposure levels of specific substances to which the worker may be exposed and for which reliable tests are available. Given the problem in predicting significant exposures for these workers, there are no clear guidelines for prescribing specific tests. The following approach identifies the types of tests that may be indicated:

- A battery of tests based on the worker's past occupational and medical history and an assessment of significant exposures
- Standard established testing for specific toxicants in situations where workers may receive significant exposures to these agents(for example, long-term exposure during cleanup of a polychlorinated biphenyls (PCB) waste facility can be monitored with pre-employment and periodic serum PCB testing); standard procedures are available for determining levels of other substances, such as lead, cadmium, arsenic, and organophosphate pesticides
- Where applicable, pre-employment blood specimens and serum frozen for later testing. (PCBs and some pesticides are examples of agents amenable to such monitoring.)

Sample Pre-Employment Examination

The Occupational Safety and Health Administration states that an occupational and medical history is to be taken for each employee enrolled in a medical-surveillance program. It should include a complete medical history emphasizing these systems:

- Nervous
- Skin
- Lung
- Blood-forming
- Cardiovascular
- Gastrointestinal
- Genitourinary
- Reproductive
- Ear, nose, and throat

The physical examination should include at least the following:

- Height
- Weight
- Temperature
- Pulse
- Respiration
- Blood pressure

An examination of the head, nose, and throat should also include the following as guidelines:

- Eyes: Include vision tests that measure refraction, depth perception, and color vision. These tests should be administered by a qualified technician or physician. Vision quality is essential to safety, the accurate reading of instruments and labels, the avoidance of physical hazards, and for appropriate response to color-coded labels and signals.
- Ears: Include audiometric tests, performed at 500, 1000, 2000, 3000, 4000, and 6000 hertz (Hz) pure tone in an approved booth (see requirements listed in 29 CFR Part 1910.95, Appendix D). Tests should be administered by a qualified technician and results read by a certified audiologist or a physician familiar with audiometric evaluation. The integrity of the eardrum should be established, since perforated eardrums can provide a route of entry for chemicals into the body. The physician evaluating employees with perforated eardrums should consider the environmental conditions of the job and discuss possible specific safety controls with the site safety officer, industrial hygienist, and/or other health professionals before deciding whether such individuals can safely work on site.
- Chest (heart and lungs)
- Peripheral vascular system
- Abdomen and rectum (including hernia exam)
- Spine and other components of the musculoskeletal system
- Genitourinary system
- Skin
- Nervous system

Tests should also include:

- Blood
- Urine
- A posterior/anterior-view chest x-ray, with lateral or oblique views only if indicated or if mandated by state regulations. The x-ray should be taken by a certified or board-certified radiologist. Chest x-rays taken in the last 12-month period, as well as the oldest x-ray available, should be obtained and used for comparison. Chest x-rays should not be repeated more than once a year unless otherwise determined by the examining physician.

Additional Medical Testing

To determine a worker's capacity to perform while wearing protective equipment, additional tests may be necessary. For example, pulmonary function testing should include forced expiratory volume, with interpretation and comparison to normal predicted values corrected for age, height, race, and sex. A permanent record of flow curves should be placed in the worker's medical records. The tests should be conducted by a certified technician and the results interpreted by a physician.

At least one standard, 12-lead resting Electrocardiogram (EKG) should be performed at the discretion of the physician. A stress test (graded exercise) may be administered at the discretion of the examining physician, particularly where heat stress may occur or other factors indicate that this is necessary.

Baseline Monitoring

If there is likelihood of potential on-site exposure to a particular contaminant, specific baseline monitoring should be performed to establish data relating to that toxicant. Employers will have to be proactive in advising the examining physician if there are particular contaminants that should be monitored for.

Periodic Medical Examinations

Periodic medical examinations should be developed and used in conjunction with pre-employment screening examinations. Comparison of sequential medical reports with baseline data is essential to determine any biologic trends that could mark early signs of adverse health effects and thereby facilitate appropriate protective measures.

The frequency and content of examinations will vary, depending on the nature of the work and exposures. Generally, medical examinations have been recommended at least yearly but must be given at least every two years. More frequent examinations may be necessary, depending on the extent of potential or actual exposure, the type of chemicals involved, the duration of the work assignment, and the individual worker's profile. The examining physician will determine the frequency of the examinations. For example, workers participating in the cleanup of a PCB-contaminated building were initially examined monthly for serum PCB levels. Review of the data from the first few months revealed no appreciable evidence of PCB exposure. The frequency of PCB testing was then reduced. Periodic screening exams can include:

- Interval medical history, focusing on changes in health status, illnesses, and possible work-related symptoms. The examining physician should have information about the worker's interval exposure history, including exposure monitoring at the job site, supplemented by worker-reported exposure history and general information on possible exposures at previously worked sites.
- Physical examination
- Additional medical testing, depending on available exposure information, medical history, and examination results. Testing should be specific for the possible medical effects of the worker's exposure. Multiple testing for a large range of potential exposures is not always useful; it may involve invasive procedures (e.g., tissue biopsy), be expensive, and produce false-positive results.

- A pulmonary-function test should be administered if the individual uses a respirator, has been or may be exposed to irritating or toxic substances, or if the individual has breathing difficulties, especially when wearing a respirator.
- Audiometric tests: annual retests are required for personnel subject to high noise exposures (an 8-hour, time-weighted average of 85 dBA or more), those required to wear hearing protection, or as otherwise indicated.
- Vision tests: annual retests are recommended to check for vision degradation
- Blood and urine test when indicated

Sample Periodic Medical Examination

The basic periodic medical examination is the same as the pre-employment screening (see above) modified according to current conditions, such as changes in the worker's symptoms, site hazards, or exposures.

Termination Examination

At the end of employment at a hazardous-waste site, all personnel should have a medical examination as described in the previous sections. This examination may be limited to obtaining an interval medical history of the period since the last full examination (consisting of medical history, physical examination, and laboratory tests) if all three following conditions are met:

- The last full medical examination was within the last 6 months.
- No exposure occurred since the last examination.
- No symptoms associated with exposure occurred since the last examination.

Table 6.5 Tests Frequently Performed by Occupational Physicians

FUNCTION	TEST	EXAMPLE
Liver:		
• General	• Blood Tests	Total protein, albumin, globulin,
• Obstruction	• Enzyme Test	(if total is elevated).
• Cell Injury	• Enzyme Tests	Alkaline phosphates.
		Gamma glutamyl
Kidney:		
• General	Blood Tests	
Multiple Systems and Organs	Urinalysis	
Blood-Forming Function	Blood Tests	

If any of these criteria is not met, a full examination is medically necessary at the termination of employment.

Emergency Treatment

Provisions for emergency treatment and acute non-emergency treatment should be made at each site. Preplanning is a vital part of the medical surveillance program. When developing plans, procedures, and equipment lists, the range of actual and potential hazards specific to the site should be considered, including chemical, physical (such as heat and/or cold stress, falls, and trips), and biologic hazards (animal bites and plant poisoning as well as hazardous biological wastes). Not only site workers but also contractors, visitors, and other personnel (particularly firefighters and regulatory officials who may frequent the site) may require emergency treatment.

Emergency medical treatment should be integrated with the overall site emergency-response program:

- Train a team of site personnel in emergency first aid. This should include a Red Cross, Medic First Aid® or equivalent certified course in cardiopulmonary resuscitation (CPR), and first-aid training that emphasizes treatment for explosion and burn injuries, heat stress, and acute chemical toxicity. (In addition, this team should include an emergency medical technician (EMT) if possible.) Table 6.6 lists signs and symptoms of exposure and heat stress that indicate potential medical emergencies.
- Train personnel in emergency decontamination procedures in coordination with the emergency response plan.
- Pre-designate roles and responsibilities to be assumed by personnel in an emergency.
- Establish an emergency/first-aid station on site, capable of providing (1) stabilization for patients requiring off-site treatment, and (2) general first aid (e.g., minor cuts, sprains, abrasions).
- Locate the station in the clean area adjacent to the decontamination area to facilitate emergency decontamination.
- Provide a standard first-aid kit or equivalent supplies, plus additional items such as emergency/deluge showers, stretchers, potable water, ice, emergency eyewash, decontamination solutions, and fire-extinguishing blankets.
- Restock supplies and equipment immediately after each use and check them regularly.
- Arrange for a physician who can be contacted by phone or pager on a 24-hour basis.
- Set up an on-call team of medical specialists for emergency consultations, including a toxicologist, dermatologist, hematologist, allergist, ophthalmologist, cardiologist, and neurologist.

Table 6.6 Signs and Symptoms of Chemical Exposure and Heat Stress that Indicate Potential Medical Emergencies

TYPE OF HAZARD	SIGNS AND SYMPTOMS
Chemical Hazard	Behaviorial changes
	Breathing difficulties
	Changes in complexions or skin color
	Coordination difficulties
	Coughing
	Dizziness
	Drooling
	Diarrhea
	Fatigue and/or weakness
	Irritability
	Irritation of eyes, nose, respiratory tract, skin, or throat
	Headache
	Light-headedness
	Nausea
	Sneezing
	Sweating
	Tearing
	Tightness in chest
Heat Exhaustion	Clammy skin
	Confusion
	Dizziness
	Fainting
	Fatigue
	Heat rash
	Light-headedness
	Nausea
	Profuse sweating
	Slurred speech
	Weak pulse
Heat Stroke (may be fatal)	Confusion
	Convulsions
	Hot skin, high temperature (yet may feel chilled)
	Incoherent speech
	Convulsions
	Staggering gait
	Sweating stops (yet residual sweat may be present)
	Unconsciousness

- Establish a protocol for monitoring heat stress.
- Make plans in advance for emergency transportation to, treatment at, and contamination control procedures for a nearby medical facility.
- Educate local emergency transport and hospital personnel about possible medical problems on site; types of hazards and their consequences; potential for exposure; and scope and function of the site medical program.
- Assist the hospital in developing procedures for site-related emergencies. This will help to protect hospital personnel and patients and to minimize delays due to concerns about hospital safety or contamination.

For specific illnesses or injuries, provide details of the incident and the worker's past medical history to the appropriate hospital staff. This is especially crucial when specific medical treatment is required, as for exposure to something like cyanide or organophosphate pesticides. Depending on the site's location and potential hazards, it may be important to identify additional medical facilities capable of sophisticated response to chemical or other exposures.

There should be a place to post conspicuously (with duplicates near the telephones) the names, phone numbers, addresses, and procedures for contacting the following:

- On-call physicians
- Medical specialists
- Ambulance services
- Medical facilities
- Emergency, fire, and police services
- Poison-control hotline

Maps should be provided as well as directions to the nearest hospital or medical-treatment facility capable of handling a contaminated or injured patient. Make sure at a minimum that all managers and all individuals involved in medical response at the site are familiar with the directions to the nearest emergency medical facility and the location of the contact phone numbers. A radio system or other suitable means of communication for emergency use must be established. It is important to review these emergency procedures daily with all site personnel at safety meetings before beginning the work shift.

Non-Emergency Treatment

Arrangements should be made for non-emergency medical care for hazardous substances. In conjunction with the medical surveillance program, off-site medical personnel should also investigate and treat non—job-related illnesses that may put the worker at risk because of task requirements (e.g., a bad cold or flu that might interfere with respirator use). A copy of the worker's medical records should be kept at the site when possible (with strict provisions for security and confidentiality) and when appropriate at a nearby hospital. Treating physicians should have access to these records.

Medical Records

Proper record keeping is essential at hazardous-waste sites because of the nature of the work and risks: employees may work at a large number of geographically separate sites during their careers, and adverse effects of long-term exposure may not become apparent for many years. Records enable subsequent medical-care providers to be informed about worker's previous and current exposures.

Occupational Safety and Health Administration (OSHA) regulations mandate that, unless a specific occupational safety and health standard provides a different time period, the employer must:

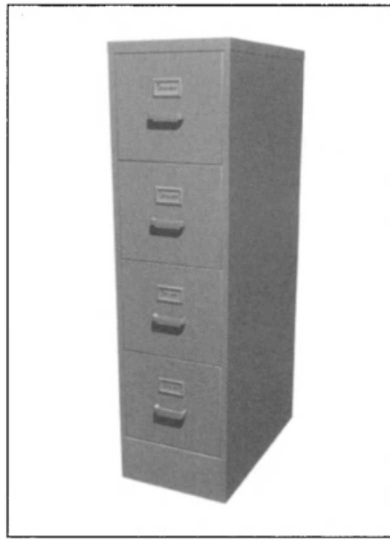


Figure 6.12 All medical surveillance records should be maintained for thirty years after an employee stops working with hazardous materials. They should be maintained in locked file cabinets.

- Maintain and preserve medical records on exposed workers for 30 years after they leave employment (29 CFR Part 1910.20)
- Make available to workers, their authorized representatives, and authorized OSHA representatives the results of medical testing and full medical records and analyses (29 CFR Part 1910.20)
- Maintain records of occupational injuries and illnesses and post a yearly summary report (29 CFR Part 1904).

Program Review and Summary

Regular evaluations of the medical program are important to ensure its effectiveness. Maintenance and review of medical records and test results assist medical personnel, site safety officers, human-resource managers, and the parent company and/or agency managers in assessing the effectiveness of the health and safety program. Medical surveillance is one of the most important topics in this book, as it pertains directly to the individual worker and his or her health. Medical surveillance is designed to benefit both employee and employer. As an employee, you (or your family) should not be penalized by becoming exposed to hazardous materials while working for any company. That's the reason for the medical examinations, follow-up examinations, and record keeping. (Records are maintained for 30 years after an employee stops working with hazardous materials per the requirements of the Hazwoper Standard.). Employers also benefit from all this testing and medical examination. They are not responsible for what I refer to as the "sins of our past" (or our past medical issues). They should not have to pay for or be responsible for any previous medical condition, a genetic problem, or a lifestyle that has affected our ability to work.

The site safety officer, medical consultant, and/or management representatives should, at least annually:

- Ascertain that each accident or illness was promptly investigated to determine the cause and make necessary changes in health and safety procedures.
- Evaluate the efficacy of specific medical testing in the context of potential site exposures
- Add or delete medical tests as suggested by current industrial hygiene and environmental data
- Review potential exposures and site safety plans at all sites to determine if additional testing or revision is required
- Review emergency treatment procedures and update lists of emergency contacts

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE MANUAL
by Brian J. Gallant

7

AIR MONITORING

Airborne contaminants can present a significant threat to worker health and safety. Thus, identification and quantification of these contaminants through air monitoring is an essential component of a health and safety program at a hazardous-waste site. Reliable measurements of airborne contaminants are useful for:

- Selecting personal protective equipment
- Delineating areas where protection is needed
- Assessing the potential health effects of exposure
- Determining the need for specific medical monitoring

This chapter describes the factors to consider when conducting air monitoring at a hazardous-waste site. It presents strategies for assessing airborne contamination at sites and describes instruments and methods for measuring exposures.

MONITORING INSTRUMENTS

The purpose of air monitoring is to identify and quantify airborne contaminants in order to determine the level of worker protection needed. Initial screening for identification is often qualitative: i.e., the contaminant, or the class to which it belongs, is demonstrated to be present, but the determination of its concentration (quantification) must await subsequent testing. Two principal approaches are available for identifying and/or quantifying airborne contaminants. They are:

- The on-site use of direct-reading instruments
- Laboratory analysis of air samples obtained by gas-sampling-bag, filter, sorbent, or wet-contaminant collection methods

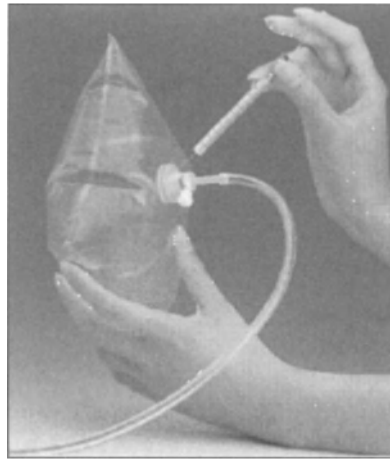


Figure 7.1 This photo depicts a gas sampling bag, often used in hazardous-waste operations

Direct-Reading Instruments

Direct-reading instruments were developed as early warning devices for use in industrial settings, where a leak or accident could release a high concentration of a known chemical into the ambient atmosphere. These date back as far as the canary in the cage, once used to detect air-quality problems in mineshafts. Today, some direct-reading instruments can detect contaminants in concentrations down to one part contaminant per million parts of air (ppm), although quantitative data is very difficult to obtain, especially when multiple contaminants are present. Information provided by direct-reading instruments is used to institute appropriate protective measures and determine the most appropriate equipment for further monitoring as well as to develop optimum sampling and analytical protocols. Table 7.1 and Table 7.2 indicate some operating information for various pieces of equipment.

Unlike air-sampling devices, which are used to collect samples for subsequent analysis in a laboratory, direct-reading instruments provide information at the time of sampling and enable rapid decision-making by supervisory personnel.

Direct-reading instruments may be used to rapidly detect flammable or explosive atmospheres, oxygen deficiency, certain gases and vapors, and ionizing radiation. They are the primary tools of initial site characterization. The information provided by direct-reading instruments can be used to institute appropriate protective measures—for example, personal protective equipment and evacuation—to determine the most appropriate equipment for more extensive monitoring and to develop optimum sampling and analytical protocols.

Figure 7.2 This photo shows the miner using the canary as his "air monitoring" instrument. Courtesy of MSHA

Table 7.1 Operation of Equipment

Instrument	Instructions
Oxygen meter	Used to measure oxygen concentrations. Read out is 0-100 %, oxygen concentration. < 19.5 % oxygen, need supplied air > 23.5 % explosion hazard as O_2 content increases. Precautions: Affected by temperature and pressure; CO_2 levels may be affected; Must be calibrated before and after each use; Requires maintenance; User must be trained.
Combustible gas indicator (CGI)	Used to sample flammable vapor concentration Read out is % LEL Reading is >10% NO ENTRY allowed Precautions: Requires periodic factory calibrations; does not respond the same to all vapors; O_2 must be measured first; CGI requires sufficient oxygen to operate properly to determine LEL; User must be trained; Must be field calibrated by qualified individual before and after each use.
Colorimetric Detector Tubes (Drager, Sensidyne, etc.)	Used to sample gas or vapor concentration in any work space Read out is as ppm or percent of concentration indicated by color change (stain) or length of color stain Precautions: Inaccurate + or – as much as 25 % of value; Limited shelf life of tubes, so check the expiration date on box; Results are affected by temperature and humidity; User must be trained; User must follow pump stroke requirements on directions; Pump must be checked for leaks periodically.

Figure 7.3 This US Geological Survey mobile lab is being set up a site in the western United States.

Table 7.2 Other Direct Reading Instruments

MONITORED	HAZARD APPLICATION	METHOD	DETECTION LIMITATIONS	OPERATION	EASE OF MAINTENANCE	GENERAL CARE AND TIMES	TYPICAL INSTRUMENT
Direct-Reading Colorimetric Indicator Tube	Specific gases and vapors.	Measures concentrations of specific gases and vapors.	The compound reacts with the indicator chemical in the tube, producing a stain whose length or color change is proportional to the compound= s concentration	The measured concentration of the same compound may vary among different manufacturer= s tubes. Many similar chemicals interfere. Greatest sources of error are (1) how the operator judges stains end-point, and (2) the tube=s limited accuracy. Affected by high humidity.	Minimal operator training and expertise required. Check expiration	Do not use a previously opened tube even if the indicator chemical is not stained. Check pump for leaks before and after use. Refrigerate prior to use to maintain shelf life of about 2 years. date of tubes. Calibrate pump volume at least quarterly. Avoid rough handling which may cause channeling.	
Oxygen Meter	Oxygen (O_2)	Measures the percentage of O_2 in air.	Uses an electro-chemical sensor to measure the partial pressure O_2 of in the air and converts that reading to O_2 concentration.	Must be calibrated prior to use to compensate for altitude and barometric pressure. Certain gases, especially oxidants such as ozone, can affect readings. Carbon dioxide CO2) poisons the detector cell.	Effective use required that the operator understand the operating principles and procedures.	Replace detector cell according to manufacturer= s recommendations. Recharge or replace batteries prior to expiration of the specified interval. If the ambient air is more than 0.5% CO_2, then replace or rejuvenate the O_2 detector cell frequently.	8 to 12 hours.

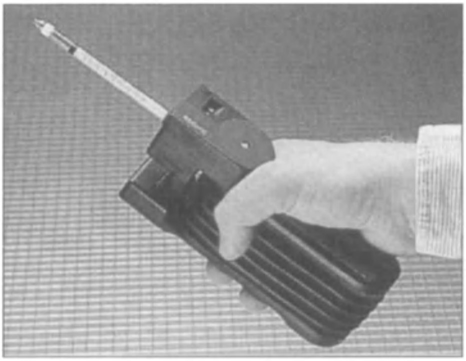


Figure 7.4 This shows a Drager pump and tube. The pump is depressed and air is drawn through the tube to get a reading.

Figure 7.5 A Sensidyne pump is shown above. The air is drawn through the pump by pulling the handle back.

All direct-reading instruments have inherent constraints in their ability to detect hazards:

- They usually detect and/or measure only specific classes of chemicals
- Generally, they are not designed to measure and/or detect airborne concentrations below 1 part per million
- Many of the direct-reading instruments that have been designed to detect one particular substance also detect other substances (interference) and, consequently may give the user a false reading

Figure 7.6 This shows a Drager Chip Analyzer. This new instrument uses a chip instead of a tube, but the process is the same as the pump, except the chip is put into the bottom of the unit and the testing is done automatically.

It is imperative that direct-reading instruments be operated and their data interpreted by qualified individuals who are thoroughly familiar with the particular devices, operating principles, and limitations and who have obtained the instruments' latest operating instructions and calibration curves. At hazardous-waste sites where unknown and multiple contaminants are the rule rather than the exception, instrument readings should be interpreted conservatively. The following guidelines may facilitate accurate recording and interpretation:

- Calibrate instruments according to the manufacturer's instructions before and after every use
- Develop chemical response curves if they are not provided by the instrument manufacturer
- Remember that the instrument's readings have limited value where contaminants are unknown. When recording readings of unknown contaminants, they should be reported as "needle deflection" or "positive instrument response" rather than specific concentrations. Conduct additional monitoring at any location where a positive response occurs.
- A reading of zero should be reported as "no instrument response" rather than "clean" because quantities of chemicals may be present that are not detectable by the instrument
- The survey should be repeated with several detection systems to maximize the number of chemicals detected

Figure 7.7 Here an instrument is being calibrated in the field.

Table 7.1 lists several direct-reading instruments and the conditions and/or substances they measure. The flame ionization detector (FID) and the photo ionization detector (PID) are commonly used at hazardous-waste sites to assess air contaminants. However, some of

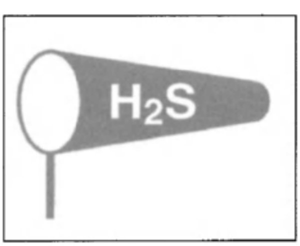


Figure 7.8 This shows a Hydrogen Sulfide (H2S) wind sock.

Figure 7.9 This shows a Flame Ionization Detector (FID).

Figure 7.10 This Infrared Spectrometer does some very sophisticated testing for specific hazards.

these devices may not detect some particularly toxic agents, including hydrogen cyanide and hydrogen sulfide. Thus, these devices must be supplemented with other methods of detection.

Laboratory Analysis

Direct-reading personal monitors are available for only a few specific substances and are rarely sensitive enough to measure the minute quantities of contaminants that may, nevertheless, induce health changes. Thus to detect relatively low-level concentrations of contaminants, long-term or full-shift personal air samples must be analyzed in a laboratory. Full-shift air samples for some chemicals may be collected with passive dosimeters or by means of a pump that draws air through a filter or sorbent. Table 7.3

Figure 7.11 This Photo Ionization Detector can be used by workers in emergencies or at waste sites.

reference to Table 7.3, but no table 7.3?

Figure 7.12 This radiation detector is used to detect levels of radioactive materials.

lists some sampling and analytical techniques used at hazardous-waste sites.

Selection of the appropriate sampling media largely depends on the physical state of the containments. For example, chemicals such as PCBs (polychlorinated biphenyls) and PNAs (polynuclear aromatic hydrocarbons) occur as both vapors and particulate-bound contaminants. A dual-media system is needed to measure both forms of these substances. The volatile component is collected on a solid absorbent and the nonvolatile component is collected on a filter. More than two dozen dual-media sampling techniques have been evaluated by the National Institute for Occupational Safety and Health (NIOSH).

A major disadvantage of long-term air monitoring is the time required to obtain the sampling information. The time lag between sampling and obtaining the analysis results may be a matter of hours, if an on-site laboratory is available, or days, weeks, even months if a remote laboratory is involved. This can be a significant problem if the situation requires immediate decisions concerning worker-safety issues. Also, by the time samples are returned from a remote laboratory, the hazardous-waste-site

Figure 7.13 Lab testing often follows field testing and provides a more accurate result than field testing.

Figure 7.14 The EPA often uses their mobile lab (shown above) for field testing. Mobile labs give faster results than sending samples to fixed labs.

Figure 7.15 This shows the interior of a lab. Note the instruments and sink.

cleanup may have progressed to a different stage or to a location at which different contaminants or completely different concentrations may exist. Careful planning and/or the use of a mobile laboratory on site may help to alleviate these problems.

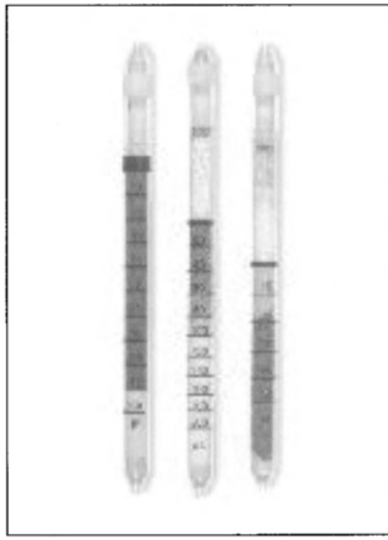


Figure 7.16 These are a sampling of Colorimetric tubes. The color staining or length of the stain is what indicates the amount of contaminant present in the air.

Mobile laboratories may be brought on site to classify hazardous wastes for disposal. A mobile laboratory is generally a trailer truck that houses analytical instruments capable of rapidly classifying contaminants by a variety of techniques. Typical instruments include gas chromatographs, spectrofluorometers and infrared spectrophotometers. When not in use in the mobile laboratory, these devices can be relocated to fixed-base facilities. On-site laboratory facilities and practices should meet standards of good laboratory safety.

Usually, a few of the field samples collected are analyzed on site to provide rapid estimates of the concentrations of airborne contaminants. This data can be used to determine the initial level of airborne contaminants and worker personal protection necessary to modify field sampling procedures and to guide the fixed-base laboratory analysis. If necessary, samples screened in the mobile laboratory can be subsequently reanalyzed in sophisticated fixed-base laboratories.

The mobile laboratory also provides storage space, countertop staging areas for hygiene equipment, and facilities for recharging self-contained breathing apparatus.

SITE MONITORING

Priorities for air monitoring should be based on the information gathered during initial site characterization. This information serves as the basis for selecting the appropriate monitoring and personal protective equipment (PPE) to use when conducting site monitoring. Depending on site conditions and project goals, four categories of site monitoring may be necessary:

- Monitoring for immediately dangerous to life and health (IDLH) conditions
- General on-site monitoring
- Perimeter monitoring
- Periodic monitoring

Monitoring for Dangerous Conditions

As a first step, air monitoring should be conducted to identify any immediately dangerous to life and health (IDLH) and other dangerous conditions, such as flammable or explosive atmospheres, oxygen-deficient environments, and any highly toxic levels of airborne contaminants. Direct-reading monitoring instruments will normally include combustible gas indicators, oxygen meters, colorimetric indicator tubes, and organic vapor monitors. Other monitoring instruments may be necessary based on the initial site characterization results and any other known situations (such as radioactive materials). When time permits, air samples should be collected for laboratory analysis. Extreme caution should always be exercised in continuing a site survey when atmospheric hazards are indicated. Personnel who are performing the monitoring should be fully aware that conditions can rapidly change from non—hazardous to hazardous.

Acutely hazardous concentrations of chemicals may persist in confined and low—lying spaces for long periods of time. Workers should look for any natural or artificial barriers, such as hills, tall buildings, or tanks behind which air might be still, allowing hazardous concentrations to build up. Examine any confined spaces, such as cargo holds, mineshafts, silos, aboveground or underground storage tanks, box-cars, buildings, cargo containers, bulk tanks, and dumps where chemical exposures capable of causing acute health effects are likely to accumulate. Low-lying areas, such as hollows and trenches, are also suspect. These spaces should be monitored for IDLH and other dangerous conditions. All results must be recorded.

In open spaces, toxic materials tend to be emitted into the atmosphere, transported away from the source, and dispersed. Thus, acutely hazardous conditions are not likely to persist in open spaces for extended periods of time unless there is a very large source, such as an overturned tank car or other obvious source of release. Open spaces are therefore generally given a lower monitoring priority, but they need to be monitored!

General On-Site Monitoring

Air sampling should be conducted using a variety of media to identify the major classes of airborne contaminants and their concentrations. The following sampling pattern can be used as a guideline. First, after visually identifying the sources of possible generation, collect air samples downwind from the designated source along the axis of the wind direction. Work upwind until reaching or getting as close as possible to the source. Level B protection should be worn during this initial sampling. Levels of protection for subsequent sampling should be based upon the results obtained and the potential for an unexpected release of chemicals.

After reaching the source or finding the highest concentration, sample along the cross-axis of the wind direction to determine the degree of dispersion. Smoke plumes or plumes of instrument-detectable airborne substances may be released as an aid in this assessment. To ensure that there is no background interference and that the detected substance(s) are originating at the identified source, also collect air samples upwind of the source.

Perimeter Monitoring

Fixed-location monitoring at the "fence line" or perimeter, where personal protective equipment is no longer required, measures contaminant migration away from the site and enables the site safety officer to evaluate the integrity of the site's clean areas. Since the fixed-location samples may reflect exposures either upwind or downwind from the site, wind speed and direction data are needed to interpret the sample results.

Periodic Monitoring

Site conditions and thus atmospheric chemical conditions may change following the initial characterization. For this reason, monitoring should be repeated periodically, especially when:

- Work begins on a different portion of the site
- Different contaminants are being handled
- A markedly different type of operation is initiated
- Workers are handling leaking drums or working in areas with obvious liquid contaminants (e.g., a spill or lagoon-

Personal Monitoring

The selective monitoring of high-risk workers—i.e., those who are closest to the source of contamination—is highly recommended. This approach is based on the rationale that the probability of significant exposure varies directly with distance from the source. If workers closest to the source are not significantly exposed, then all other workers are presumably also not significantly exposed and probably do not need to be monitored.

Since occupational exposures are linked closely with active material handling, personal air sampling should not be necessary until site mitigation has begun. Personal monitoring samples should be collected in

Figure 7.17 Personal air monitors are used by workers to get instant readings of exposure.

the breathing zone and, if workers are wearing respiratory protective equipment, outside the face piece. These samples represent the actual inhalation exposure of workers who are not wearing respiratory protection and the potential exposure of workers who are wearing respiratory protection . It is best to use pumps that automatically maintain a constant flow rate to collect samples, since it is difficult to observe and adjust pumps while wearing gloves, respirators, and other personal protection.

Personal monitoring may require the use of a variety of sampling media. Unfortunately, single workers cannot carry multiple sampling media because of the added strain and because it is not usually possible to draw air through different sampling media using a single portable, battery-operated pump. Consequently, several days may be required to measure the exposure of a specific individual using each of the media. Alternatively, if workers are in teams, a different monitoring device can be assigned to each team member. Another method is to place multiple sampling devices on pieces of heavy equipment. While these are not personal samples, they can be collected very close to the breathing zone of the heavy-equipment operator and thus would be reasonably representative of personal exposure. These multimedia samples can yield as much information as several personal samples.

Variables of Hazardous-Waste Site Exposure

Complex, multi-substance environments such as those associated with hazardous-waste sites pose significant challenges to accurately and safely assessing airborne contaminants. Several independent and uncontrollable variables, most notably temperature and weather conditions, can affect airborne concentrations. These factors must be considered when developing an air-monitoring program and when analyzing data.

Some demonstrated variables include:

- Temperature
- Moisture
- Rainfall
- Vapor emission
- Wind speed
- Work activities and tasks being performed

Limitations and Advantages of Monitoring Equipment

All direct-reading instruments have inherent constraints in their ability to detect hazards at waste sites and during emergency situations. Some of those limitations are:

- Detect and/or measure only specific substances
- One meter does not perform all measurements
- Can cause interference and report false readings
- Not generally designed to measure and/or detect concentrations below 1 ppm

Some advantages include:

- Information is immediately available at the site
- Available for a wide range of potential hazards
- Measures chemicals that cause acute health effects and IDLH situations
- Identification of high levels of toxic and flammable atmospheres
- Determines whether or not the atmosphere within a space is safe for entry (toxic, flammable, oxygen deficient?)

SUMMARY

Air monitoring confirms whether the suspected hazardous substances at a site or during an emergency are present in the work environment or not. Many of the decisions related to employee protection and workplace safety procedures are a direct result of knowing the identification and quantification of the harmful contaminants at the site. Although no single instrument can detect all hazards, proper use of monitoring equipment by a qualified individual can provide information needed to protect worker safety and the environment.

We will rely on instruments and the personnel operating them to make some major decisions almost daily as we work at hazardous-waste sites. Remember to get training to operate the various instruments that your company uses, keeping in mind that every instrument is a bit different. If you are unfamiliar with the operation of the unit, please ask a supervisor.

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE MANUAL
by Brian J. Gallant

8

PERSONAL PROTECTIVE EQUIPMENT

INTRODUCTION

All personnel entering an uncontrolled hazardous-waste site must be protected against any potential hazards they may encounter. The purpose of personal protective clothing and equipment is to shield or isolate individuals from the chemical, physical, and biological hazards presented by a waste site. Careful selection of adequate personal protective equipment (PPE) should protect the following:

- Respiratory system
- Skin and body
- Face and hands
- Feet and legs
- Head
- Hearing

This chapter describes the various types of personal protective equipment that are appropriate for use on uncontrolled hazardous-waste sites and provides guidance in their selection and use. We will also look at some other issues, including heat stress, and other key physiological factors that must be considered in connection with the use of personal protective equipment.

The use of personal protective equipment is regulated by the Occupational Safety and Health Administration (OSHA) regulations in 29 CFR and is reinforced by the

United States Environmental Protection Agency (EPA), regulation 40 CFR, which requires all private contractors and their personnel working on Superfund sites to conform to the applicable Occupational Safety and Health Administration provisions, as well as any other federal or state safety requirements determined to be necessary by the lead agency overseeing the hazardous-waste activities on the site.

No single piece of protective equipment, or any combination of equipment and clothing, is capable of protecting workers against all hazards that may be encountered in the performance of duties at hazardous-waste sites. As a matter of fact, there probably is no protective equipment capable of providing protection against even one threat for a prolonged period of time. (Eventually, all protective equipment will wear or become damaged.) Therefore, personal protective equipment should be considered to be the last option for protection of workers. It should always be used in conjunction with other protective methods such as safety procedures and policies, alternative remedial actions, and/or engineering controls.

The use of personal protective equipment in itself often creates significant worker hazards, such as but not limited to the following:

- Heat stress
- Physiological stress
- Impaired visibility
- Mobility
- Communications

(Note: It is a fact that wearing personal protective equipment makes a job more expensive. It takes longer to complete the job; and it causes more stress on the workers. Nonetheless, if it is needed for the job, personal protective equipment must be worn.)

I have been involved with situations when using protective equipment has hindered personnel in the field. In each of those cases I have had to make adjustments to the work assignment or the equipment involved in the operation. A good example would be wearing protective garments or outer suits during weather situations in excess of 95 degrees F. A work/rest regime may be an option to consider, or you can provide a cooling vest to workers who may be at risk. Another alternative to protective clothing may be to modify the requirements to wearing the suit only to the waist. These options/alternatives will need to be evaluated on a case-by-case basis by the safety officer.

The greater the level of personal protective equipment, the greater the associated risks. For any given situation, equipment and clothing should be selected to provide an adequate level of protection. Overprotection of personnel is also hazardous and should be avoided. If there is no need for personnel to wear personal protective equipment, they should not be wearing it.

DEVELOPING A PERSONAL PROTECTIVE EQUIPMENT PROGRAM

Companies will need to develop a written personal-protective-equipment program as a major component of the overall worker protection plan. This is done in writing so that everyone involved can read and understand the requirements, and if necessary, the plan can be revised and upgraded when appropriate. There are two basic objectives for any PPE program to be effective. Those objectives are:

- To protect the wearer from environmental threats
- To prevent injury to the wearer from incorrect use and/or malfunction of the equipment

To accomplish these important goals, a comprehensive personal protective equipment program must include medical monitoring, hazardous-material identification, environmental surveillance, and careful personal protective equipment selection, use, and decontamination. The remainder of this chapter discusses the following PPE program elements:

- Selection of respiratory protection and related equipment
- Selection of personal protective clothing and items
- Selection of an overall level of protection (ensemble)
- Equipment use

Equipment Use

Most people feel that it is easy to use personal protective equipment. "Just give it to me and I'll put it on," most workers say. There's quite a bit more to it than that. Equipment use is further broken down into:

- Training
- Work duration
- Heat stress and other physiological factors
- Personal use factors
- Donning
- Respirator-fit testing
- In-use monitoring
- Doffing
- Inspection
- Storage
- Maintenance

Figure 8.1 This worker is being fit tested for a respirator.

In developing an effective personal-protective-equipment program, it is essential that all elements of the program be put in writing. An employer should develop an appropriate format, which includes policy statements, company procedures, and guidelines. This written program should be made available to all employees involved with hazardous-waste operations. There should also be a reference copy available at each work site so that if questions arise, they can be researched and answered quickly. If the document is in a loose-leaf notebook, it should include technical data on equipment, maintenance manuals, relevant regulations, and other essential information such as appendices. I would also recommend that any easily dated material such as personnel names, addresses, and phone numbers be placed in the appendices. Managers should review and revise the manuals at least annually, but preferably after each program evaluation or as otherwise needed.

Program Review and Evaluation

The personal-protective-equipment program, as part of an overall comprehensive safety and health program, must be periodically reviewed and evaluated. Elements that should be considered as part of the review process include but are not limited to the following:

- Number of person-hours in various protective ensembles
- Accident or illness experience and type
- Levels of exposure

- Appropriateness of the equipment selection
- Adequacy of the operational guidelines
- Adequacy of the decontamination, cleaning, inspection, maintenance, and storage program
- Coordination with overall safety and health program elements
- Program costs
- Degree of fulfillment of program objectives
- Adequacy of program records and record-keeping requirements
- Recommendations for program improvement and modification

The results of the program evaluation should be made available to the affected employees and presented to top management so that adaptations may be implemented. Personnel are more apt to participate in a program if they are included in its development.

SELECTION OF PROTECTIVE CLOTHING

Protective clothing is considered to be any article or garment offering skin and/or body protection. It covers a wide variety of options. The photographs show some examples of protective clothing. They include:

- Fully encapsulating suits
- Non-encapsulating suits
- Aprons, leggings, and sleeve protectors
- Gloves
- Firefighter's protective clothing
- Proximity, or approach, garments
- Blast and fragmentation suits
- Cooling garments or vests
- Anti-contamination (radiation) suits

Figure 8.2 This worker is shown wearing a fully encapsulated suit comprising Level A protection.

Examples of Protective Clothing

Each type of protective clothing has a specific purpose. Many, but not all, are designed to protect against chemical exposure. Chemical-protective clothing is available in a variety of materials that offer a range of resistances to different chemicals. The most appropriate

Figure 8.3 The two workers on the right are wearing non encapsulating suits, while the worker on the far left is in a fully encapsulated suit. Note the difference.

Figure 8.4 These are two examples of chemical resistant gloves.

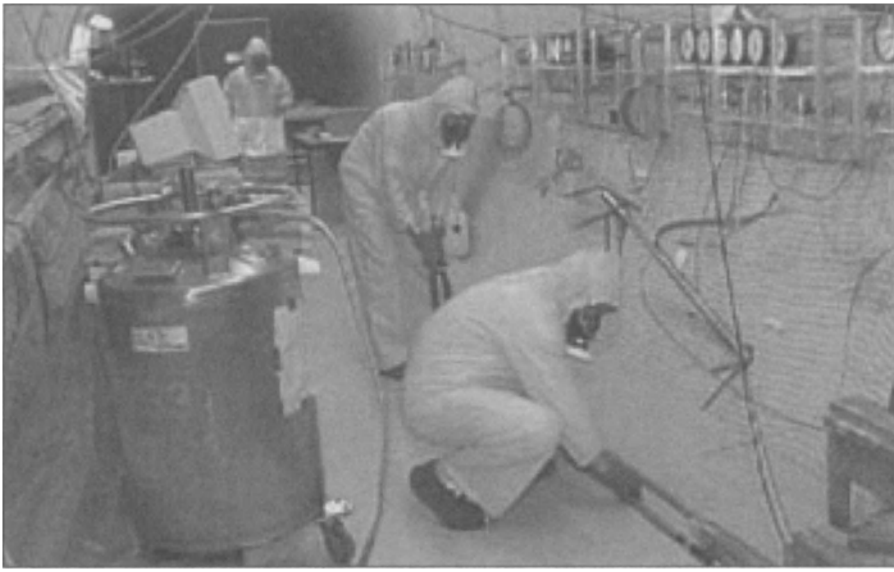


Figure 8.5 These workers are wearing radiation protective garments, referred to as anti contamination clothing (anti c's).

clothing fabric/material will depend on the chemicals that are present at the work site. Ideally, the chosen material will resist degradation (a chemical reaction between the chemical and the material, resulting in damage to the material) and permeation (the seepage of a chemical substance through the material). However, no material protects against all chemicals and combinations of chemicals, and no material is an effective barrier to any prolonged chemical exposure. Table 8.1 provides information on protective clothing that may be useful for personnel.

Selection of Chemical Protective Clothing (CPC)

The selection of chemical protective clothing is a very complex task that should be performed by personnel with training and experience. Personal-protective-equipment selection generally occurs under the following three circumstances:

- The contaminants are known, identified, or at least classified
- The contaminants are unknown
- Special hazards exist that require specialized protective equipment

Under each of these conditions, protective clothing should be selected by evaluating the performance characteristics of the clothing against the requirements and limitations of the waste site, as well as any task-specific conditions that may be involved in the operations being conducted.

Table 8.1 Chemical protective clothing

BODY PART PROTECTED	TYPE OF CLOTHING OR ACCESSORY	DESCRIPTION	TYPE OF PROTECTION	USE CONSIDERATIONS
Full Body	Fully encapsulating suit	One-piece garment. Boots and gloves may be integral, attached and replaceable, or separate.	Protects against splashes, dust, gases, and vapors.	Does not allow body heat to escape. May contribute to heat stress in wearer, particularly if worn in conjunction with a closed-circuit SCBA; a cooling garment may be needed. Impairs worker mobility, vision, and communication.
	Non-encapsulating suit	Jacket, hood, pants, or bib overalls and one-piece coveralls.	Protects against splashes, dust, and other material, but not against gases and vapors. Does not protect parts of head or neck.	Do not use where gas-tight or pervasive splashing protection is required. May contribute to heat stress in wearer. Tape-seal connections between pant cuffs and boots and between gloves and sleeves.
	Aprons, leggings, and sleeve protectors	Fully sleeved and gloved apron. Separate coverings for arms and legs. Commonly worn over non-encapsulating suit.	Provides additional splash protection of chest, forearms, and legs.	Whenever possible, should be used over a non-encapsulating suit (instead of using a fully encapsulating suit) to minimize potential for heat stress. Useful for sampling, labeling, and analysis operations. Should be used only when there is a low probability of total body contact with contaminants.
	Firefighter's protective clothing	Gloves, helmet, running or bunker coat, running or bunker pants (NFPA Standard No.1971, 1972, 1973), and boots.	Protects against heat, hot water, and some particles. Does not protect against gases and vapors or chemical permeation or degradation. NFPA Standard No. 1971 specifies that a	Decontamination is difficult. Should not be worn in areas where protection against gases, vapors, chemical splashes, or permeation is required.

Table 8.1 Chemical protective clothing (*continued*)

BODY PART PROTECTED	TYPE OF CLOTHING OR ACCESSORY	DESCRIPTION	TYPE OF PROTECTION	USE CONSIDERATIONS
Full Body (*continued*)			garment consist of an outer shell, an inner liner, and a vapor barrier with a minimum water penetration of 25 lbs/in2 (1.8 kg/cm2) to prevent the passage of hot water.	
	Proximity garment (approach suit)	One or two-piece overgarment with boot covers, gloves, and hood of aluminized nylon or cotton fabric. Normally worn over other protective clothing, such as chemical-protective clothing, firefighter-bunker gear, or flame-retardant coveralls.	Protects against brief exposure to radiant heat. Does not protect against chemical permeation or degradation. Can be custom-manufactured to protect against some chemical contaminants.	Auxiliary cooling and an SCBA should be used if the wearer may be exposed to a toxic atmosphere or needs more than two or three minutes of protection.
	Blast and fragmentation suit	Blast and fragmentation vests and clothing, bomb blankets, and bomb carriers.	Provides some protection against very small detonations. Bomb blankets and baskets can help redirect a blast.	Does not provide hearing protection.
	Radiation contamination protective suit	Various types of protective clothing designed to prevent contamination of the body by radioactive particles.	Protects against alpha and beta particles. *Does NOT protect against gamma radiation.*	Designed to prevent skin contamination. If radiation is detected on site, consult an experienced radiation expert and evacuate personnel until the radiation hazard has been evaluated.
	Flame/fire-retardant coveralls	Normally worn as an undergarment.	Provides protection from flash fires.	Adds bulk and may exacerbate heat stress problems and impair mobility.

(*continues*)

Table 8.1 Chemical protective clothing (*continued*)

BODY PART PROTECTED	TYPE OF CLOTHING OR ACCESSORY	DESCRIPTION	TYPE OF PROTECTION	USE CONSIDERATIONS
Full Body (*continued*)	Flotation gear	Life jackets or work vests. (Commonly worn underneath chemical protective clothing to prevent flotation gear degradation by chemicals.)	Adds 15.5 to 25 lbs (7 to 11.3 kg) of buoyancy to personnel working in or around water.	Adds bulk and restricts mobility. Must meet USCG standards (46 CFR Part 160).
	Cooling garment	One of three methods: (1) A pump circulates cool, dry air throughout the suit or portions of it via an air line. Cooling may be enhanced by use of a vortex cooler, refrigeration coils, or a heat exchanger. (2) A jacket or vest having pockets into which packets of ice are inserted. (3) A pump circulates chilled water from a water/ice reservoir and through circulating tubes, which cover part of the body (generally the upper torso only).	Removes excess heat generated by worker activity, the equipment, or the environment.	(1) Pumps circulating cool air require 10 to 20 ft3 (0.3 to 0.6 m3) of respirable air per minute, so they are often uneconomical for use at a waste site. (2) Jackets or vests pose ice storage and recharge problems. (3) Pumps circulating chilled water pose ice storage problems. The pump and battery add bulk and weight.
Head	Safety helmet (hardhat)	For example, a hard plastic or similar helmet.	Protects the head from blows and falling objects.	Helmet must meet OSHA standard 29 CFR Part 1910.135.
	Helmet liner		Insulates against cold. Does not protect against chemical splashes.	
	Hood	Commonly worn with a helmet.	Protects against chemical splashes, particulates, and rain.	

Table 8.1 Chemical protective clothing (*continued*)

BODY PART PROTECTED	TYPE OF CLOTHING OR ACCESSORY	DESCRIPTION	TYPE OF PROTECTION	USE CONSIDERATIONS
Head (*continued*)	Protective hair covering		Protects against chemical contamination of hair. Prevents the entanglement of hair in machinery or equipment. Prevents hair from interfering with vision and with the functioning of respiratory protective devices.	Particularly important for workers with long hair.
Eyes and Face*	Face Shield	Full-face coverage, eight-inch minimum.	Protects against chemical splashes. Does not protect adequately against projectiles.	Face shields and splash hoods must be suitably supported to prevent them from shifting and exposing portions of the face or obscuring vision. Provides limited eye protection.
	Splash hood		Protects against chemical splashes. Does not protect adequately against projectiles.	
	Safety glasses		Protect eyes against large particles and projectiles.	If lasers are used to survey a site, workers should wear special protective lenses.
	Goggles		Depending on their construction, goggles can protect against vaporized chemicals, splashes, large particles, and projectiles (if constructed with impact-resistant lenses).	Splash protection

(*continues*)

Table 8.1 Chemical protective clothing (*continued*)

BODY PART PROTECTED	TYPE OF CLOTHING OR ACCESSORY	DESCRIPTION	TYPE OF PROTECTION	USE CONSIDERATIONS
	Sweat bands		Prevents sweat-induced eye irritation and vision impairment.	Hot environments
Ears	Earplugs and muffs		Protect against physiological damage and psychological disturbance.	Must comply with OSHA regulation 29 CFR Part 1910.95. Can interfere with communication efforts in the field. Use of earplugs should be carefully reviewed by a health and safety professional because chemical contaminants could be introduced into the ear.
	Headphones	Radio headset with throat microphone.	Provide some hearing protection while enabling communication.	Highly desirable, particularly if emergency conditions arise.
Hands and Arms	Gloves and sleeves	May be integral, attached, or separate from other protective clothing.	Protect hands and arms from chemical contact.	Wear jacket cuffs over glove cuffs to prevent liquid from entering the glove. Tape-seal gloves to sleeves to provide additional protection.
		Overgloves.	Provide supplemental protection to the wearer and protect more expensive undergarments from abrasions, tears, and contamination.	
		Disposable gloves.	Should be used whenever possible to reduce decontamination needs.	

Table 8.1 Chemical protective clothing (*continued*)

BODY PART PROTECTED	TYPE OF CLOTHING OR ACCESSORY	DESCRIPTION	TYPE OF PROTECTION	USE CONSIDERATIONS
Foot	Safety boots	Boots constructed of chemical-resistant material.	Protect feet from contact with chemicals.	
		Boots constructed with some steel materials (e.g., toes, shanks, insoles).	Protect feet from compression, crushing, or puncture by falling, moving, or sharp objects.	All boots must at least meet the specifications required under OSHA 29 Part 1910.136 and should provide good traction.
		Boots constructed from nonconductive, spark-resistant materials or coatings.	Protect the wearer against electrical hazards and prevent ignition of combustible gases or vapors.	

Contaminants Identified or Classified

The selection of chemical protective clothing (CPC) depends greatly upon the type and physical state of the contaminants involved. This information is usually determined during the site characterization phase of the project. Once the chemicals have been identified (or at least placed into a hazard class), the safety officer or other management representative should consult available information sources to determine a garment's resistance to permeation and degradation by the known chemicals and its heat- transfer characteristics as described below. This information can be used to narrow down the appropriate options; then, if possible, the appropriate person can physically inspect representative garments before purchasing and discuss the use and performance factors with someone who has previous experience with the actual clothing under similar conditions or circumstances.

Permeation and Degradation

When reviewing the vendor's literature, safety personnel should be aware that the data provided may be of limited value in some cases for several reasons. For example, the quality of vendor test methods ranges from state-of-the-art to nonexistent. Vendors frequently rely on the raw-material manufacturers for data rather than conducting their own specific testing. The data may not be updated as additional information becomes available. In no way does vendor information address the wide variety of uses and challenges to which chemical protective clothing (and thus the wearer) may be subjected. Most vendors strongly emphasize this point in the descriptive text that accompanies their data tables or sales literature. Also, keep in mind that the rate of permeation is a function of several factors including: clothing material type and thickness, manufacturing method, the concentration of the hazardous substance, temperature, pressure, humidity (to some extent), the solubility of the chemical in the suit's material, and the diffusion coefficient of the permeating chemical in the material. What I'm trying to say is that permeation rates may vary depending on some of these conditions. The following generalizations are helpful and may be applicable:

- Temperature: Permeation rates increase and breakthrough times decrease with increasing temperatures. The degree of reduction in protective performance depends on the chemical and the material.
- Thickness: For a given clothing material, permeation is inversely proportional to thickness: i.e., doubling the thickness theoretically halves the permeation rate. Breakthrough time (the time from initial exposure until the hazardous material is detectable on the inside of the suit) is directly proportional to the square of the thickness, thus doubling the thickness theoretically quadruples the breakthrough time.

The permeation rate is a direct function of the solubility of the chemical in the material; however, workers need to use care and caution in interpreting solubility data. If you don't understand the data, ask for clarification. Low solubility does not necessarily correspond to low permeation rates. The diffusion coefficient is also a direct factor in permeation rate. Gases, for example, are low in solubility but have high diffusion coefficients and may permeate protective clothing at rates several times greater than a liquid with moderate to high solubility in the material. Information on solubility and diffusion coefficients may be found in vendor literature or literature on permeation testing (as well as some other technical resources that may be used for this purpose).

When trying to determine protective garment (suit) penetration rates, multi-component liquids can pose a problem, due to lack of experience in and information available on permeation and degradation. Mixtures of chemicals can be (and often are) significantly more aggressive towards plastics and rubbers than any one of the components alone. Even small amounts of a rapidly permeating chemical may provide a pathway that speeds up the permeation rate of other chemicals. Research is being performed by several of the manufacturers to develop accurate data on these effects. In the meantime, immersion and permeation testing are recommended as the best means of selecting protective clothing for multi-component solutions. Several protective clothing manufacturers are presently attempting to develop a protocol for field immersion degradation testing. Permeation testing is lagging due to a lack of data and research in that particular area.

Heat-Transfer Characteristics

The heat-transfer characteristics of personal protective equipment are important factors in the selection process. Since most chemical protective clothing is virtually impermeable to moisture, evaporative cooling does not occur. The thermal insulation value of chemical protective clothing influences heat loss through means other than evaporation. The larger the thermal insulation value, the greater the insulating properties of the garment and, consequently, the lower the heat transfer. Given other equivalent protective properties, supervisory personnel responsible should select the lowest thermal insulation value in hot environments or for high work rates.

Unknown Contaminants

Unfortunately, at many hazardous-waste sites, the contaminants are often not identified or quantified until after the equipment-selection process is completed and the garments are used. In such cases a suit (or several suits) may be pre-selected from those offering the widest range of protection against the chemicals or types of substances that workers will be expected to encounter.

However, after selecting such a suit or suits, the presence of any hazardous materials known to chemically attack (degrade or permeate) the selected suits must be ruled out. This "rule-out" is usually accomplished by using gas-detector tubes or chip analyzers to test for those chemicals known to (or expected to) permeate. Since permeation data is limited at present, it may not always be possible to completely rule out chemicals that can permeate personal-protective-equipment materials.

The presence of degrading and/or permeating chemicals does not necessarily rule out the use of the suit. For example, butyl rubber rapidly degrades if exposed to nitric acid for more than 20 minutes, but a butyl-rubber suit may still be used in the presence of nitric acid, in a relatively safe manner, to effect a ten minute rescue or to perform a minor work task. On the other hand, the suit then must be retired from use (disposed of properly) after this assignment or rescue is completed.

Figure 8.6 This shows one style of hard hat. There are various styles on the market, including one that looks like a cowboy hat!

Other Considerations

In addition to permeation, degradation, and heat resistance several other factors must be considered during the clothing-selection process. These affect not only chemical resistance but also the worker's ability to perform the required task safely.

The following checklist summarizes these considerations:

- Chemical resistance: Does the clothing have design or construction imperfections that would allow hazardous materials to permeate (e.g., stitched seams, buttonholes, porous zippers, pinholes)?
- Durability: Does the material have sufficient strength to withstand the physical stress of the task(s) at hand? Will the material resist tears, punctures, and

Figure 8.7 This shows several styles of safety glasses that are on the market today. Some of the more stylish types are shown.

abrasions? Will the material withstand repeated use after contamination and decontamination?

- Flexibility: Will the workers be able to perform their assigned tasks (particularly important to consider for gloves)?
- Temperature effects: Will the material maintain its protective integrity and flexibility under hot and cold extremes?
- Ease of decontamination: Are decontamination procedures available on site? Will the material pose any decontamination problems? If so, what are they? Should disposable clothing be used?
- Compatibility with other equipment: Does the clothing preclude the use of another, necessary piece of protective equipment (e.g., suits that preclude hardhat use in areas that require the use of hardhats)?

Selection of Ensembles

Up to this point, only the individual components of a personal protective equipment ensemble have been described. The ultimate goal, however, is to assemble the necessary components into a full protective ensemble that both protects the worker from the site-specific hazards and minimizes the hazards and drawbacks of the personal-protective-equipment ensemble itself. See Table 8.2 for sample ensembles.

Figure 8.8 This shows a protective hood worn by a worker.

Figure 8.9 Face shields should be worn when there is a splash potential. Safety goggles should be worn in combination with the shield.

Table 8.2 Sample Protective Ensemble

LEVEL OF PROTECTION	EQUIPMENT	PROTECTION PROVIDED	SHOULD BE USED WHEN	LIMITING CRITERIA
A	RECOMMENDED: • Pressure-demand, full face piece SCBA or pressure-demand supplied-air respirator with escape SCBA. • Fully encapsulating, chemical-resistant suit. • Inner chemical-resistant gloves. • Chemical-resistant safety boots/shoes. • Two-way radio communications. OPTIONAL • Cooling unit. • Coveralls. • Long cotton underwear. • Hardhat. • Disposable gloves and boot covers.	The highest available level of respiratory, skin, and eye protection.	• The chemical substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on either: • measured (or potential for) high concentration of atmospheric vapors, gases, or particulates or • site operations and work functions involving a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the intact skin. • Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible. • Operations must be conducted in confined, poorly ventilated areas until the absence of conditions requiring Level A protection is determined.	Fully encapsulating suit material must be compatible with the substances involved. • Use only when the vapor or gases present are not suspected of containing high concentrations of chemicals that are harmful to skin or capable of being absorbed through the intact skin.

Table 8.2 Sample Protective Ensemble (*continued*)

LEVEL OF PROTECTION	EQUIPMENT	PROTECTION PROVIDED	SHOULD BE USED WHEN	LIMITING CRITERIA
B	RECOMMENDED: • Pressure-demand, full-face piece SCBA or pressure-demand supplied-air respirator with escape SCBA. • Chemical-resistant clothing (overalls and long-sleeved jacket; hooded, one- or two-piece chemical splash suit; disposable chemical-resistant one-piece suit). • Inner and outer chemical-resistant gloves. • Chemical-resistant safety boots/shoes. • Hardhat. • Two-way radio communications. OPTIONAL: • Coveralls. • Disposable boot covers. • Face shield. • Long cotton underwear.		• The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection but less skin protection. This involves atmospheres: • with IDLH concentrations of specific substances that do not represent a severe skin hazard: or • that do not meet the criteria for use of air-purifying respirators. • Atmosphere contains less than 19.5 percent oxygen. • Presence of incompletely identified vapors or gases is indicated by direct-reading organic vapor detection instrument, but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the intact skin.	• Use only when it is highly unlikely that the work being done will generate either high concentrations of vapors, gases, or particulates or splashes of material that will affect exposed skin.

(*continues*)

Table 8.2 Sample Protective Ensemble (*continued*)

LEVEL OF PROTECTION	EQUIPMENT	PROTECTION PROVIDED	SHOULD BE USED WHEN	LIMITING CRITERIA
D	RECOMMENDED: • Coveralls. • Safety boots/shoes. • Safety glasses or chemical splash goggles. • Hardhat. OPTIONAL: • Gloves. • Escape mask. • Face shield.		• The atmosphere contains no known hazard. • Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.	• This level should not be worn in the Exclusion Zone. • The atmosphere must contain at least 19.5 percent oxygen.

In putting together an ensemble, please note that the National Institute for Occupational Safety and Health (NIOSH) approves a fully encapsulated suit with (1) either an air-line respirator, a combination air-line/self-contained breathing apparatus, or a self-contained breathing apparatus worn inside the suit, or (2) a breathable air supply providing air directly to the fully encapsulating suit through an air inlet valve. Currently there are no NIOSH approvals given for ensembles in which the respirator face piece is an integral part of the suit.

The clothing worn inside a personal-protective-equipment-ensemble will depend on the ambient temperature, but I would suggest the minimum clothing, even in hot weather, should be cotton, long-john-type underwear. While this may seem a bit strange to most of us, such garments absorb perspiration and act as a "wick" for evaporation, consequently aiding in the cooling process of the wearer. Long underwear or similar garments will also protect the skin from any contact with hot inner suit surfaces, reducing the possibility of burns in hot weather situation.

These lists should be considered as a starting point for protective-equipment-ensemble creation. The ensembles should be customized to the specific situation at the work site in order to provide the most appropriate level of protection and safety for the wearer. If any work is being conducted at a highly contaminated site or the potential for contamination is high, it may be advisable to wear a disposable garment covering over the suit. Tyvek® coveralls or polyester splash suits can be used as an outer garment. (This will protect the inner suit from any potentially heavy contamination that may be encountered.) A slit may have to be made in the back of these suits to fit around the bulge of the encapsulating suit and the self-contained breathing apparatus (depending on the manufacturer and the type of breathing apparatus being worn). Table 8.3 displays information on the use of ensembles. Table 8.4 describes Level A suits and Table 8.6 summarizes Level D protective clothing.

Table 8.3 Use of Ensembles

1. Inspect all pieces of the clothing and the respiratory equipment before donning.
2. Adjust hardhat or headpiece if worn to fit user's head.
3. Open back closure used to change air tank (if suit has one) before donning suit.
4. Standing or sitting, step into the legs of the suit; ensure proper placement of the feet within the suit; then pull the suit up and gather the suit around the waist.
5. Put chemical-resistant safety boots over the feet of the suit. Tape the leg cuffs over the tops of the boots.
   - If additional chemical-resistant boots are required, put them on now.
   - Some one-piece suits have heavy-soled protective feet. With these suits, wear short, chemical-resistant safety boots inside the suit.
6. Put on air tanks and harness assembly of the SCBA. (All SCBA steps will depend on the style of suits and the manufacturer of the breathing apparatus. These steps are generally accurate.) Don the face piece and adjust it to be secure but comfortable. Do not connect the breathing hose. Open valve on air tank.

Table 8.3 Use of Ensembles ***(continued)***

7. Perform negative and positive respirator face-piece-seal test procedures:
   - To conduct a negative-pressure test, close the inlet part with the palm of the hand or squeeze the breathing tube so it does not pass air and gently inhale for about ten seconds. Any inward rushing of air indicates a poor fit. Note that a leaking face piece may be drawn tightly to the face to form a good seal, giving a false indication of adequate fit.
   - To conduct a positive-pressure test, gently exhale while covering the exhalation valve to ensure that a positive pressure can be built up. Failure to build a positive pressure indicates a poor fit.
8. Depending on type of suit:
   - Put on long-sleeved inner gloves (nitrile are lightweight, thin, and similar to surgical gloves—however, no surgical gloves are to be used!).
   - Secure gloves to sleeves for suits with detachable gloves (if not done prior to entering the suit).
   - Additional overgloves, worn over attached suit gloves, may be donned later.
9. Put sleeves of suit over arms as the assistant pulls suit up and over the SCBA. Have assistant/buddy adjust suit around SCBA and shoulders to ensure safe fit and unrestricted motion.
10. Put on hardhat if needed. It will likely need to have a chin strap to keep it in place.
11. Raise hood over head carefully so as not to disrupt face seal of SCBA mask. Adjust hood to give satisfactory comfort.
12. Begin to secure the suit by closing all fasteners until there is only adequate room to connect the breathing hose. Secure all belts and/or adjustable leg-, head-, and waistbands.
13. Connect the breathing hose while opening the main valve (depends on the type of SCBA used).
14. Have assistant/buddy first ensure that wearer is breathing properly and then make final closure of the suit.
15. Have assistant/buddy check all closures and tape if necessary or procedurally required.
16. Have assistant/buddy observe the wearer for a short period of time to ensure that the wearer is comfortable and psychologically stable and that the equipment is functioning properly.

Reasons to Upgrade Levels of Protection

Safety officers generally select the proper level of protective clothing for the workers, using all information that is currently available. As we have been stating, at many sites there may be a need to upgrade the level of protective garments for workers. Some of these reasons include but are not limited to the following:

- Known or suspected presence of dermal chemicals
- Imminent danger of fire or explosion

- Occurrence or likely occurrence of detonation or toxic-gas emission
- Change in work task that will increase contact or potential contact with hazardous materials
- Request of individual performing task

Reasons to Downgrade Levels of Protection
Just as we discussed the potential for upgrading our levels of protection, there also may be good reasons to downgrade our level of personal protective equipment. Some reasons include but are not limited to the following:

- New information is provided or researched, indicating that the situation at hand is less hazardous than originally thought
- Air or other monitoring reveals that the situation is less hazardous, perhaps due to engineering controls or other reason
- Change in site conditions that decreases the hazard(s) present
- Change in work assignment(s) that will essentially reduce contact with hazardous substances

PERSONAL PROTECTIVE EQUIPMENT USE

Personal protective equipment can offer the highest degree of protection only if it is used correctly and worn properly. This section covers the following aspects of PPE use:

- Training requirements
- Work mission duration
- Personal use factors
- Donning
- Fit testing requirements
- In-use monitoring
- Doffing
- Inspection
- Storage
- Maintenance

Failure to pay close attention to any one of these items could result in protective clothing and/or equipment that is inappropriate or unsafe for use. This places the wearer at risk.

Table 8.4 Level A suits

EQUIPMENT	PROTECTION PROVIDED	SHOULD BE USED WHEN	LIMITING CRITERIA
RECOMMENDED: Pressure-demand, full face piece SCBA or pressure—demand supplied -air respirator with escape SCBA. Fully encapsulating, chemical-resistant suit. Inner chemical-resistant gloves. Chemical-resistant safety boots/shoes. Two-way radio communications. OPTIONAL: • Cooling unit. • Coveralls. • Long cotton underwear. • Hardhat. • Disposable gloves and boot covers.	The highest available level of respiratory, skin, and eye protection.	The chemical substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on either: • measured (or potential for) high concentration of atmospheric vapors, gases, or particulates or • site operations and work functions involving a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the intact skin. • Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible. • Operations must be conducted in confined, poorly ventilated areas until the absence of conditions requiring Level A protection is determined.	Fully encapsulating suit material must be compatible with the substances involved.

Training

Training in personal-protective-equipment use is required under the Hazardous Waste Operations and Emergency Response standard. Training provides personnel the following:

- Allows the user to become familiar with the equipment in a nonhazardous and controlled situation
- Instills the confidence of the user in his/her equipment
- May increase the protective efficiency of personal-protective-equipment use
- Reduces the expenses related to maintaining the equipment

Training should be conducted at least annually and realistically should be completed prior to actually using the personal protective equipment in a hazardous or dangerous environment. (This will help to ensure that the knowledge and practice are fresh in the wearer's mind.) At a minimum, the training portion of the personal-protective-equipment program should outline the user's responsibilities and explain the following (utilizing both classroom and field training when necessary and appropriate):

- The operation of the selected personal protective equipment, including capabilities and limitations
- The nature of the hazards and the consequences of not using the personal protective equipment

Figure 8.10 The worker is shown wearing Level A protection.

Figure 8.11 The worker is wearing Level B protection.

Figure 8.12 This worker is shown in Level C protection. Level C uses an air purifying respirator.

- The human factors influencing personal-protective-equipment performance
- Training in inspecting, donning, doffing, checking, and fitting personal protective equipment
- Individualized quantitative personal-protective-equipment fitting
- Use of personal protective equipment in normal air for a long familiarity period and, wearing personal protective equipment in a test atmosphere to evaluate its effectiveness
- The user's responsibility for decontamination, cleaning, maintenance, and repair of personal protective equipment (if any is needed and person is qualified to perform it)
- How to recognize emergency situations while using/wearing protective equipment
- Emergency procedures and self-rescue in the event of personal-protective-equipment failure
- The buddy system
- The site emergency plan and the individual's responsibilities and duties in an emergency

Figure 8.13 This outer garment worn by a hazardous waste worker would be considered Level D protection, as would any coverall or typical work uniform

Since personal-protective-equipment use often causes discomfort and inconvenience, there is a natural resistance to wearing it conscientiously by some workers at hazardous-waste sites. The major thrust of training must be to make the user aware of the need for personal protective equipment and to instill in him/her the motivation to wear and maintain the necessary personal protective equipment properly.

Work Duration

Before the workers actually begin work in their personal-protective-equipment ensembles, be it sampling, drum handling, or some other task, the anticipated duration of the work should be determined as soon as possible. Several factors limit work duration. Some of those factors include:

- Oxygen/breathing air supply consumption
- Suit/ensemble penetration by contaminant(s)

- Coolant supply
- Ambient temperature

Suit/Ensemble Penetration
The possibility of ensemble penetration during the work assignment should always be a matter of concern. Some of the possible causes of ensemble penetration are as follows:

- Suit valve leakage, particularly under excessively hot or cold temperatures
- Suit fastener leakage if the suit is not properly maintained or if the fastener becomes brittle or cracked at cold temperatures
- Exhalation valve leakage at excessively hot or cold temperatures

When considering mission or assignment duration, remember that every piece of chemical-resistant clothing has certain limitations. These limitations include the following:

- No single clothing material is an effective barrier to all chemicals or all combinations of chemicals
- No material is an effective barrier to prolonged chemical exposure
- Against certain chemicals and chemical combinations, no commercially available clothing (or glove) provides more than one hour of protection following contact

Coolant Supply
The amount of coolant supply carried by the wearer significantly influences the work assignment's duration. If coolant (ice or chilled air) is necessary to maintain workers at a comfortable temperature, the duration of the coolant supply will directly affect the duration of the assignment. Adequate coolant should be provided to allow workers to complete the task(s) in comfort, as heat stress is a significant danger. Remote coolant supplies such as supplied-air suits or two-stage refrigeration systems can extend duration at the expense of a trailing umbilical cord and increased ensemble complexity. Cool vests are also a good source of coolant for workers and are relatively inexpensive.

Donning an Ensemble
The wearer must understand all aspects of the clothing's operation and its limitations; this is especially important for full-body encapsulating ensembles where misuse could potentially result in suffocation.

The donning of a full-encapsulating suit/SCBA ensemble is a relatively simple task, but a routine must be established and practiced frequently. Donning an encapsulating suit can be difficult when done by the user alone. This also increases the possibility of damaging the protective suit. Therefore, it is important to be sure that assistance is provided for both donning and doffing this equipment. Keep in mind that the buddy system is in place for just this type of situation! Don't try to be the superman by struggling with the donning/doffing. You have a buddy, so ask for help and offer to help your partner as well.

Figure 8.14 Cooling vests like this one help workers from overheating.

The procedures that follow for donning a full-encapsulating suit/SCBA ensemble are general guidelines for certain types of suits. (These guidelines can be used for most of the major manufacturers.) These procedures should be modified for the particular suit and/or when extra gloves and/or boots are used or required. These procedures also assume that the wearer has previous training in wearing a fully encapsulating suit, SCBA use, and decontamination procedures.

When donning a suit, the use of a moderate amount of talcum powder to prevent chafing and to increase comfort is suggested. Talcum powder will also reduce rubber binding. (It can tend to make a mess, especially if personnel are dressing indoors. This can be a slip hazard, as well.) It is suggested that personnel perform the following procedures in the order indicated below: [repeats Table 8.3]

- Inspect the clothing and respiratory equipment before donning each piece of equipment
- Adjust hardhat or headpiece, if worn, to fit user's head
- Open back closure to change air, if suit has one, before donning suit
- Standing or sitting, step into the legs of the suit; assure proper placement of the feet within the suit; and then gather the suit around the waist
- Put on, over the feet of the suit, chemical-resistant steel-toe and shank boots; properly attach and affix leg over top of boots
- If additional chemical-resistant boots are required, put these on now
- Some one-piece suits have heavy-soled protective feet; with these suits, wear safety leather or short rubber safety boots inside the suit
- Put on air tank and back-plate harness assembly of the SCBA; don the face piece and adjust it to be secure but comfortable; do not connect the breathing hose; open valve to air tank
- Perform negative and positive respirator test procedures "Respirator Fit Testing."
- Depending on the type of suit:

Figure 8.15 The tent in the background and the accompanying power source help to keep workers cool at a site in the southern US.

1. Put on long-sleeved inner gloves (lightweight gloves—nitrile works well)
2. Secure gloves to sleeves for suits with detachable gloves (if not done prior to entering suit).
3. Additional over gloves, worn over attached suit gloves, may be donned later if required

- Put sleeves of suit over arms as assistant/buddy pulls up and over the SCBA; buddy/assistant adjusts suit around SCBA and shoulders to assure unrestricted motion
- Raise hood over head carefully so as not to disrupt face seal of SCBA mask; adjust hood to head to give satisfactory comfort
- Begin to secure the suit by closing all fasteners of opening until there is only adequate room to connect the breathing hose; secure all belts and/or adjustable leg-, head-, and waist bands
- Connect the breathing hose while opening the main valve
- Buddy/assistant ensures that wearer is breathing properly, and then makes final closure of the suit
- Buddy/assistant checks all closures
- Buddy/assistant observes the wearer for a period of time to assure that he/she is comfortable, psychologically stable, and the equipment is functioning properly

Figure 8.16 These workers are shown donning suits prior to entering the hot zone.

Once the equipment is donned, the fit should be evaluated. If the clothing is too small, the worker's movement will be restricted, which increases the likelihood of tearing the material (making the ensemble ineffective and unsafe) and may greatly accelerate worker fatigue. If the clothing is too large, the possibility of snagging the material is increased, and the dexterity and coordination of the worker may be compromised. In either case, the worker should be refitted with clothing that fits better.

As a general rule of thumb, I would recommend selecting a size that is two sizes larger than what you normally take (for example if you wear a large (L) T-shirt, select an extra extra large (XXL) suit. This will allow movement in the suit and won't be as cumbersome. Remember that you are already wearing clothing under the suit in some cases, so you'll need to account for that clothing when selecting the suit size. During training sessions, the wearer should try suits of various sizes so that a proper size is known before any field activity takes place.

Doffing an Ensemble

Exact procedures for removing fully encapsulating suit/SCBA ensembles must be established and followed in an effort to prevent contaminant migration from the work area(s) and transfer of contaminants to the wearer's body, the doffing assistant/buddy, and others, as well as to clean areas.

The following procedure assumes that appropriate decontamination procedures, commensurate with the type(s) and degree of contamination, have already occurred. This procedure also assumes the availability of a properly attired buddy. Throughout the procedure, avoid any contact with the outside surface of the suit, as this spreads contamination. These are the logical steps:

- Remove any extraneous or disposable clothing, boot covers, or gloves
- Buddy/assistant loosens and removes the steel-toe and shank boots
- Buddy/assistant opens front of suit completely, lifts the hood over the head of the wearer, and rests it on top of the self-contained breathing-apparatus tank.
- Remove arms, one at a time, from suit; once arms are free, assistant lifts suit up and away from the self-contained breathing-apparatus backpack, avoiding any contact between the outside surface of the suit and the wearer's body, and lays the suit out flat behind the wearer; leave internal gloves on, if any
- Sitting, if possible, remove both legs from the suit
- After suit is removed, remove internal gloves by rolling them off, inside out
- Wearer then proceeds to the clean area and follows procedure for doffing the self-contained breathing apparatus
- Then remove internal clothing and thoroughly cleanse the body (shower)

The procedures just listed assume that a sufficient air supply is available, allowing appropriate decontamination before removal. However, if the low-pressure warning alarm has sounded, alerting that approximately three to five minutes of air are remaining, follow these procedures:

- Remove all disposable outer clothing
- Quickly scrub and hose off, especially around the entrance/exit zipper
- Open the zipper enough to allow access to the regulator and breathing hose
- Immediately attach an organic vapor, acid gas, dust mist, or fume canister to the breathing hose to provides\ protection against any contamination still present.
- Follow steps one through nine of the regular doffing procedure, taking extra care and caution to avoid contaminating the assistants/buddies and the wearer

Clothing Reuse

Chemicals that have begun to permeate clothing during use may not be removed from garments during decontamination and may continue to diffuse through the material toward the inside surface, presenting the hazard of direct skin contact to the next person who uses the clothing.

Where such potential hazards may develop, clothing should be checked inside and out for discoloration or, if possible, by wipe-testing for suspect chemicals before reuse. This is particularly important for full-body encapsulating suits, which are generally subject to reuse due to their high cost. It should be noted, however, that negative (i.e., no chemical found) test results do not necessarily preclude the possibility that some absorbed chemical will reach the suit's interior over time.

At present, very little documentation exists regarding clothing reuse, primarily because garments are disposed of properly rather than reused. Those individuals making reuse decisions must consider the known factors of permeation rates as well as the toxicity of the contaminant(s). In fact, unless extreme care is taken to ensure thorough decontamination, the reuse of chemical protective clothing with highly toxic chemicals is not advisable.

Inspection

An effective personal-protective-equipment inspection program will, in all probability, feature five different inspections. Those inspections are as follows:

- Inspection and operational testing of equipment received from the factory or distributor
- Inspection of equipment when it is issued to workers
- Inspection after use or training and prior to maintenance
- Periodic inspection of stored equipment
- Periodic inspection when a question arises concerning the appropriateness of the selected equipment or when problems with similar equipment arise

Each inspection will cover somewhat different areas in various degrees of depth. Detailed inspection procedures, where appropriate, are usually available from the manufacturer and should be followed. Table 8.8 will give some guidelines for inspecting personal protective equipment.

Records must be kept of all inspection procedures and findings. One easy way to document findings is to assign individual identification numbers to all reusable pieces of equipment (many companies use respirators that may have identification numbers already) and maintain records by that identification number. In conjunction with each inspection, the inspector should record as a minimum the following:

- Identification number
- Piece of equipment or equipment type
- Date and time
- Inspector's name
- Any unusual conditions or findings

A periodic review of these records may indicate an item or type of item with excessive maintenance costs, dependability, or a particularly high level of "down time" or operability.

Storage

Clothing and respirators must be stored properly to prevent damage or malfunction due to exposure to:

- Moisture
- Sunlight
- Damaging chemicals
- Extreme temperatures
- Impact

Procedures need to be specified for both pre-issuance warehousing and, more importantly, post-issuance (in-use) storage. Many equipment failures can be directly attributed to improper storage.

The following are some storage tips for clothing:

- Store contaminated clothing in an area separate from street clothing
- Store contaminated clothing in a well-ventilated area, with good air flow around each item if possible
- Do not mix different types of materials of clothing and gloves in storage

HEAT STRESS AND OTHER PHYSIOLOGICAL FACTORS

Wearing impermeable or semipermeable protective clothing and equipment puts a hazardous-waste worker at considerable risk for developing heat stress (the inability to release body heat), a condition that can range from transient heat fatigue and lowered work tolerance to serious illness or death. Heat stress is caused by a number of interacting factors, including environmental conditions, clothing, workload, and individual characteristics of the worker. Because heat stress is probably one of the most common (and potentially serious) illnesses at hazardous waste sites, regular monitoring and other preventive precautions are vital. Table 8.9 gives some heat-related information.

Individuals vary in their susceptibility to heat stress. Factors that may predispose someone to heat stress include:

- Lack of physical fitness
- Lack of acclimatization
- Age
- Dehydration
- Obesity

- Alcohol and drug use
- Infection
- Sunburn
- Diarrhea
- Chronic disease

The amount and type of personal protective equipment worn are directly related to reduced work tolerance and the risk of heat stress. Semipermeable and impermeable clothing and equipment add weight and bulk and diminish or prevent liquid and vapor exchange. This often results in the following:

- Severe reduction in the body's normal heat exchange mechanisms (evaporation, convection, andradiation)
- Significant increase in energy expenditure (a chemical protective garment can increase by two to four times the amount of energy ordinarily needed to perform a given task)

Therefore, when you are selecting personal protective equipment, carefully evaluate each item's health benefit against its potential for increasing heat-stress risk to the wearer. Once protective equipment is selected, determine the length of the work period based on:

- Work rate
- Ambient temperature and other environmental factors
- Type of protective ensemble selected
- Individual worker characteristics

Monitoring

Although common sense always plays a critical role in evaluating worker safety issues regarding heat, equipment is available for monitoring heat stress. Several manufacturers have developed instruments. The wet bulb globe thermometer (WBGT) is one such instrument.

Some general guidelines to follow when considering heat stress monitoring include:

- Because the occurrence of heat stress depends on a variety of factors, all workers, even those not wearing protective equipment, should be monitored
- For workers wearing permeable clothing (e.g., standard cotton or synthetic work clothes), follow recommendations for monitoring requirements and suggested work/rest schedules in the heat-stress instrument manufacturer's man-

ual; if the actual clothing worn differs from the recommended ensemble in insulation value and/or wind and vapor permeability, change the monitoring requirements and work/rest schedules accordingly. For workers wearing semi-permeable or impermeable encapsulating ensembles, monitor when the ambient temperature is above 70F; it may also be necessary to monitor at lower temperatures if the humidity is high—consult weather information daily as necessary

- Although no protective ensemble is "completely" impermeable, for practical purposes an outfit may be considered impermeable when calculating heat-stress risk. To monitor the worker, you can use these guidelines. Measure the following:
  - Heart rate: Count the worker's radial pulse during a 30-second period immediately following the end of a work period. If the worker's heart rate exceeds 140 beats per minute at the end of a work period and 100 beats per minute at the end of a rest period, shorten the next work cycle by one-third or lengthen the rest period by one-third. If the heart rate still exceeds 140 beats per minute at the end of the next work cycle, shorten the following work cycle by one-third or lengthen the rest period by one-third.
  - Oral temperature: Use a clinical thermometer (three minutes under the tongue) or similar device. If oral temperature exceeds 99.6F, shorten the next work cycle by one-third or lengthen the rest period by one-third. If oral temperature still exceeds 99.6F at the end of the next work cycle, shorten the following work cycle by one-third or lengthen the rest period by one-third. Do not permit a worker to wear a semi permeable or impermeable garment when his/her oral temperature exceeds 100.6F.
  - Skin temperature: measure worker's medial high temperature after skin temperature reaches its equilibrium level (usually, after just ten minutes of work in the heat). If skin temperature exceeds 96.8EF (36EC), a worker will have difficulty maintaining an acceptable heat balance; consider stopping all work in the heat. If skin temperature exceeds 98.6EF (37EC), stop all work in the heat
  - Body weight: measure at the beginning and end of each work day to see if enough fluids are being taken to prevent dehydration; do not allow more than a 1½ percent body weight loss in a work day (this may be difficult to do in the field, as a scale may not always be available)

The frequency of physiological monitoring depends on the air temperature and the level of physical work activities to be performed. The length of the work cycle will be governed by the frequency of the required physiological monitoring.

Figure 8.17 A wet bulb globe thermometer is used for heat evaluation.

Prevention

Proper training and preventive measures will help avert serious illness and loss of work productivity. Preventing heat stress is particularly important because once someone suffers from heat stroke or heat exhaustion, that person is predisposed to additional heat-related injuries. To avoid heat stress, the safety officer and company management should take the following steps:

- Adjust work schedules as needed
- Modify work/rest schedules according to monitoring requirements (generally, for every one hour of work, allow thirty minutes of rest)
- Mandate work slowdowns as needed (supervisors and safety personnel need to be closely involved with this.)
- Urge workers to maintain normal weight levels; encourage the drinking of fluids whenever possible
- Provide cooling devices to aid natural body ventilation during prolonged work or severe heat exposure
- Field showers or hose-down areas to reduce body temperature and/or cool off protective clothing
- Use cooling jackets, vests, or suits when appropriate
- Wear long cotton underwear to help absorb moisture and protect skin from direct contact with heat-absorbing protective clothing
- Train workers to recognize and treat heat stress

Table 8.5 Heat-Related Information

Heat rash may result from continuous exposure to heat or humid air.

Heat cramps are caused by heavy sweating with inadequate electrolyte replacement. Signs and symptoms include:

- muscle spasms
- pain in the hands, feet, and abdomen

Heat exhaustion occurs from increased stress on various body organs including inadequate blood circulation due to cardiovascular insufficiency or dehydration. Signs and symptoms include:

- pale, cool, moist skin
- heavy sweating
- dizziness
- nausea
- fainting

Heat stroke is the most serious form of heat stress. This is a true medical emergency. Temperature regulation fails and the body temperature rises to critical levels. Immediate action must be taken to cool the body before serious injury and death occur. Competent medical help must be obtained. Signs and symptoms are:

- red, hot, usually dry skin
- lack of or reduced perspiration
- nausea
- dizziness and confusion
- strong, rapid pulse
- coma

COLD WEATHER OPERATIONS

Unfortunately, we cannot choose the type of weather or the part of the country where we work. Just as we might be dealing with heat-related illnesses and injuries, we could also be facing bouts with cold weather. Before the workers begin singing, "Baby, it is COLD outside!", planning should be done to consider what actions need to be taken in cold environments.

No matter what kind of work you may be assigned, those winter weather hazards must be kept in mind when planning your activities. If you're heading out into cold or inclement weather, use common sense. Extreme cold can cause hypothermia and death. Listen to emergency broadcasts and be sure that you understand what winter-storm-warning terms mean:

Table 8.6 Level D Protection

EQUIPMENT	PROTECTION PROVIDED	SHOULD BE USED WHEN	LIMITING CRITERIA
RECOMMENDED: Coveralls. • Safety boots/shoes. • Safety glasses or chemical splash goggles. • Hard hat. OPTIONAL: • Gloves. • Escape mask. • Face shield. No respiratory protection. Minimal skin protection The atmosphere contains no known hazard. • Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals. • This level should not be worn in the Exclusion Zone. • The atmosphere must contain at least 19.5 percent oxygen.	No respiratory protection. Minimal skin protection	The atmosphere contains no known hazard. • Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.	• This level should not be worn in the Exclusion Zone. • The atmosphere must contain at least 19.5 percent oxygen.

Table 8.7 Sample Personal Protective Equipment Inspection checklists

PROTECTIVE CLOTHING (GARMENTS)

Before each use:

- Determine that the clothing material is correct for the specified task at hand.
- Visually inspect for:
  - imperfect seams
  - non-uniform coatings
  - tears
  - malfunctioning closures
- Hold up to light and check for pinholes.
- Flex product:
  - observe for cracks
  - observe for other signs of shelf deterioration
- If the product has been used previously, inspect inside and out for signs of chemical attack:
  - discoloration
  - swelling
  - stiffness

During the work task, periodically inspect for:

- Evidence of chemical attack such as discoloration, swelling, stiffening, and softening. Keep in mind, however, that chemical permeation can occur without any visible effects.
- Closure failure.
- Tears.
- Punctures.
- Seam discontinuities.

GLOVES

Before use: pressurize glove to check for pinholes. Blow into glove, then roll gauntlet towards fingers or inflate glove and hold under water. In either case, no air should escape.

FULLY-ENCAPSULATING SUITS

Before use:

- Check the operation of pressure relief valves.
- Inspect the fitting of wrists, ankles, and neck.
- Check faceshield, if so equipped, for:
  - Cracks
  - Crazing
  - Fogginess

Table 8.7 Sample Personal Protective Equipment Inspection checklists (*continued*)

RESPIRATORS

Self Contained Breathing Apparatus

- Inspect SCBAs:
  - Before and after each use
  - At least monthly when in storage
  - Every time they are cleaned
- Check all connections for tightness.
- Check material conditions for:
  - Signs of pliability
  - Signs of deterioration
  - Signs of distortion
- Check for proper setting and operation of regulators and valves (according to manufacturer's recommendations).
- Check operation of alarm(s).
- Check faceshields and lenses for:
  - Cracks
  - Crazing

Supplied-Air Respirators

- Inspect SARs:
  - Daily when in use
  - At least monthly when in storage
  - Every time they are cleaned
- Inspect air lines prior to each use for cracks, kinks, cuts, frays, and weak areas.
- Check for proper setting and operation of regulators and valves (according to manufacturer's recommendations).
- Check all connections for tightness.
- Check material conditions for:
  - Signs of pliability
  - Signs of deterioration
  - Signs of distortion
- Check faceshields and lenses for:
  - Cracks
  - Crazing
  - Fogginess

Air-Purifying Respirators

- Inspect air-purifying respirators:
  - Before each use to be sure they have been adequately cleaned
  - After each use
  - During cleaning
  - Monthly if in storage for emergency use

Table 8.7 Sample Personal Protective Equipment Inspection checklists (*continued*)

- Check material conditions for:
  - Signs of pliability
  - Signs of deterioration
  - Signs of distortion
- Examine cartridges or canisters to ensure that:
  - They are the proper type for the intended use
  - The expiration date has not been passed
  - They have not been opened or used previously
- Check faceshields and lenses for:
  - Cracks
  - Crazing
  - Fogginess

- Winter weather advisory: Conditions are likely to cause inconvenience and hazards
- Frost/freeze warning: Temperatures will drop below freezing
- Winter storm watch: A storm is likely to occur
- Winter storm warning: A storm is coming or has already arrived
- Blizzard warning: Seek shelter immediately — conditions could include snow, blowing snow, strong winds, low visibility, snow drifts, and life-threatening wind chills

Workers should take extra care to pace themselves, resting frequently to avoid straining their hearts. Always let the supervisor know if you are going outside for an extended period of time. Tell them what you plan to do, where you are going, and how long you expect to be gone. Always use the buddy system and a cell phone or other means of communications.

Be prepared with the right kind of clothing before you start any cold-weather activity. Concentrate on keeping your extremities warm: head, hands, and feet. The key is to stay warm and dry. Loose-fitting layers of clothing will help to do both. Outer garments should be tightly woven and water-repellent when that meets the personal-protective-equipment requirements. Avoid wearing cotton clothing; it tends to trap moisture next to the skin rather than wick it away. In especially cold weather, covering your mouth with a face mask can protect your lungs by warming extremely cold air as it is being inhaled.

Remember that winter weather can create dangerous road conditions and often make it hard for drivers to see where they're going. If you're on foot when it's cold and wet, watch for slippery surfaces and look out for motorists in the work area. They may be having trouble slowing down, stopping, or even seeing you.

You may not feel hot during a winter workday the way you do in summer, but dehydration is still occurring. Have sufficient water available for the crew. Never eat snow! Eating snow lowers your body temperature faster than it satisfies your thirst. Drinking water or other fluids is the way to avoid dehydration, and while warm drinks can have a rejuvenating effect, remember that caffeine drinks will speed dehydration and alcohol will increase your body's rate of heat loss. Alcohol is never allowed on the work site!

Caffeine and alcohol can also worsen the symptoms of hypothermia and frostbite. If you are going to be out in the cold for an extended period of time, watch out for these signs of frostbite:

- A "pins and needles" sensation followed by numbness
- Skin that feels hard and looks white
- Thawed skin that turns red and painful
- Blistered or black skin tissue

Also be on the lookout for these signs of hypothermia:

- Uncontrolled shivering
- Slow speech
- Memory loss or forgetfulness
- Stumbling
- Sleepiness/Lethargy
- Extreme exhaustion

If you notice any of these symptoms in yourself or someone else, report them to the safety officer and seek a warm shelter and medical attention as soon as possible.

If weather conditions outside are too extreme, consider stopping work activity, or perhaps a work/rest regime, as discussed in the heat related section, should be considered.

OTHER FACTORS

Personal protective equipment decreases work performance as compared to an unequipped individual. The magnitude of this effect varies considerably, depending on both the individual and the personal-protective-equipment ensemble selected for use. This section discusses the demonstrated physiological responses to personal protective equipment, the individual human characteristics that play a factor in these responses, and some of the precautionary and training measures that need to be taken to avoid personal protective equipment-induced injury or illness.

Physical Condition

This is the most important factor in a person's ability to endure work. (This doesn't mean that workers have to be at the gym everyday. It does mean that they need to take care of themselves.) The higher the degree of fitness, the greater the workload one can safely tolerate. At a given level of work, a fit person, relative to an unfit person, will have:

- Less physiological strain
- A lower heart rate
- A lower rectal temperature, which indicates less retained body heat (a rise in internal temperature precipitates heat injury)
- A more efficient sweating mechanism
- Slightly lower air consumption
- Slightly lower carbon-dioxide production

Figure 8.18 This picture shows an example of frostbite to a worker's foot.

Note that at every workload (as represented by oxygen uptake), the trained (fit) individual is able to work for a longer period of time than the untrained individual. This suggests that fitness training will enable workers to perform longer assignments. In general, the workload should not exceed 50 percent of the worker's work capacity. If it does, then the duration of the task may be compromised.

Level of Acclimatization

Acclimatization refers to the physiological changes occurring within an individual that reduce the strain caused by environmental heat stress. An acclimatized individual who is unaccustomed to working in the heat is at risk in this type of environment. The acclimatized person also begins to sweat sooner and sweats more often. This enables him/her to maintain a lower body temperature at a given heat stress load than a non-acclimatized person. Sweat composition also becomes more diluted with acclimatization, so less salt is lost .

Acclimatization can occur after just a few days of exposure to a hot environment. I, personally, recommend a progressive six-day acclimatization period for the nonacclimatized worker before allowing him/her to do full work on a hot job (high heat environment when the worker is not used to that climate). Begin the first day with 50 percent of the anticipated workload and exposure time and add 10 percent each day through day six. With fit or trained individuals, the acclimatization period may be shortened two or three days.

However, enclosed in an impermeable suit, a fit, acclimatized individual may actually face a greater danger of heat-related illness than an unfit individual who is not used to the climate. This is because the fit, acclimatized individual sweats more than a non-acclimatized individual. This higher sweat rate may actually contribute to rapid dehydration and an earlier onset of heat exhaustion than might occur in an unfit individual. This can be prevented by consuming adequate quantities of water. Workers should avoid the consumption of caffeine or soft drinks. Water or an electrolyte replacement fluid such as PowerAde is recommended. Workers should be encouraged to drink frequently and not to wait until they feel thirsty. If they are thirsty, they are not drinking enough! Frequent urination is also encouraged. If they are not urinating frequently, they are not drinking enough, and they run the risk of suffering from a heat-related illness.

Age

Generally, maximum work capacity declines with increasing age, but this is not always the case. Active, well-conditioned seniors often have performance capabilities equal to or greater than younger sedentary individuals. Older workers also appear to become dehydrated more frequently and have a greater risk of heat stroke. At moderate thermal loads, however, the physiological responses of "young" and "old" are similar and performance is not generally affected.

Sex

My experience in the industry indicates that females tolerate heat stress at least as well as their male counterparts. Not all males have greater work capacities than all females. Therefore maximal performance, rather than gender, is more appropriate in the selection of workers.

Weight

The ability of a body to dissipate heat depends on the ratio of its surface area to its mass (surface area/weight). Heat loss (dissipation) is a function of surface area. Heat production is dependent on mass. Heat balance is determined by the ratio of the two. Obese and/or stocky individuals produce a lot of heat but do not have a proportionately large surface area. Hence, they are not capable of rapidly dissipating the heat they produce and are more susceptible to heat-related illnesses. In comparison, thin individuals have less body volume and nearly the same surface area as an overweight person and are able to dissipate heat much more rapidly. Therefore, I would suggest that anyone who exceeds his/her standard weight by 15 percent or more be observed closely while working in a hot environment for extended periods of time. The use of height and weight tables is not recommended; I would prefer to use the common-sense approach and observe the individual(s) carefully. More valid procedures are skin-fold measurements and hydrostatic weighing, but they are more sophisticated and typically are not done in the field.

Maintenance

The technical depth of maintenance procedures on hazardous-waste equipment varies. Many manufacturers frequently restrict the sale of certain personal-protective-equipment parts to those specially trained, equipped, and "authorized" to purchase them. Companies should adopt and enforce precise procedures to ensure that maintenance is performed only by those having this specialized training, parts, and tools. The following classification scheme is often used to divide maintenance into three levels:

- Level 1: User or wearer maintenance, requiring a few common tools or no tools at all
- Level 2: Shop maintenance, which can be performed by the owner's/company's maintenance shop
- Level 3: Specialized maintenance, which can be performed only by the factory, an authorized repair depot, or qualified and trained service technician

SUMMARY

The importance of chemical protective clothing is obviously a huge factor in the success of any hazardous-waste site operation. Many critical components comprise the protective equipment program at companies that deal with hazardous waste and emergency response. While no one item outweighs another, it is important to recognize that each is integral to a safe and healthy work environment. Donning and doffing are important, but so is the selection process and the evaluations involved in determining heat/cold factors and other health-related personnel issues.

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE MANUAL
by Brian J. Gallant

9

DECONTAMINATION PROCEDURES

INTRODUCTION

Decontamination is the process of removing or neutralizing contaminants that have accumulated on personnel, equipment, and sampling containers used during hazardous-waste site operations. Decontamination stations are set up for this purpose.

The purpose of decontamination is to ensure that the contaminants remain in the hot zone. All personal protective equipment, tools, supplies, or materials that exit the hot zone must be cleaned to prevent the spread of dangerous substances to the environment, personnel, co-workers, and/or family members. Decontamination procedures include a plan, decontamination methods and procedures, and emergency decontamination.

It is possible, to some extent, through standard operating procedures (SOPs) and engineering controls, to prevent a certain amount of contamination. However, the nature of work at a hazardous-waste site limits the effectiveness of these approaches in totally preventing contamination of persons, vehicles, tools, clothing, and protective equipment and, of course, the individuals and items used to clean up other persons and things contaminated at the work site.

There are both physical and chemical means of removing contaminants. Physical methods might include rinsing, wiping, scraping, and brushing. Chemical methods might include use of solvents, surfactants, and disinfectants. (Chemicals are never used to decontaminate personnel.) The effectiveness of these measures can be observed visually, by swipe testing, or through more sophisticated methods, such as sampling and analysis.

GENERAL PROCEDURES

Decontamination should be performed before breaks and meals, after each shift, or any other time that a worker leaves the contaminated area. Specific decontamination methods and procedure vary according to location of:

- Contaminants
- Equipment
- Facilities
- Specific contaminants involved

Site zones, consisting of the exclusion zone, contamination reduction zone, and support zone, or the hot, warm, and cold zones, are designated to control contaminants and direct personnel from dirty to clean areas on the work site. Table 9.1 shows when decontamination is required.

Proper decontamination procedures must:

- Control hazards
- Prevent permeation of substances into the PPE, equipment, tools, etc.
- Position decontamination line in an area that eliminates the transfer of contaminants to workers in the clean areas of the work site
- Prevent uncontrolled transfer of contaminants to the community
- Prevent mixing of incompatible substances
- Be monitored to ensure that the process is effective and be revised as needed

Table 9.1 Decontamination

When PPE becomes contaminated
When clothing becomes contaminated
Before workers eat, drink, smoke, chew or use the rest room facilities
Before workers leave the area
Before workers apply lip balm or sun block

PREPLANNING FOR DECONTAMINATION

Proper decontamination or replacement of protective clothing or equipment is a critical element in controlling the spread of contaminants that exist in and around hazardous-waste areas. The decontamination plan must be operational before any personnel or equipment enters an area where the potential for exposure to hazardous substances exists.

There are hazards involved in the decontamination process. Decontaminants, for example, may not be compatible with the contaminants they are supposed to remove or neutralize. There are often respiratory dangers, which is why protective clothing is needed in some of these situations.

Among the equipment used during decontamination are plastic drop cloths or tarpaulins, disposal drums, wash and rinse solutions, long-handled brushes, plastic trash bags, shower facilities, and lockers for clean clothing and personal items. Heavy equipment and vehicle decontamination may require such additional items as storage tanks, spray booths, shovels, pressure washers, buckets, and brooms. Containers are needed to store and dispose contaminated wash and rinse solutions as well as equipment and tools. Decontamination equipment itself must often be disposed of properly, because it cannot be fully cleaned.

Table 9.2 outlines the information to be included in a decontamination plan.

Table 9.2 Decontamination plan

Description of the location and layout of the decontamination stations
List of the decontamination equipment needed at each station
Appropriate PPE for persons assisting with decontamination
Specific procedures for decontamination of site specific substances
Methods and procedures for preventing contamination of clean areas
Methods and procedures for minimizing worker contact with contaminants
Safe disposal methods for PPE that is not completely cleaned
Revisions when changes effect the type of PPE, or the equipment being used, site conditions change, and/or the hazards are reassessed as a result of updated information

PERSONAL PROTECTIVE EQUIPMENT

Figure 9.1 Long handled brushes like this are often used in decontamination efforts. They are easy to obtain, inexpensive and if necessary, can be disposed of properly.

The level of personal protective equipment required for decontamination workers increases as the level of contamination increases. Level D protection consists of a work uniform that may include coveralls or a protective garment to protect the worker's personal clothing. Level C includes a protective garment (depending on the

Figure 9.2 Workers here are using a 3,000 psi pressure washer to clean equipment.

Figure 9.3 One worker is shown exiting from a roll off container, while his partner prepares for decontamination. Notice how heavily contaminated the outer garments are.

contaminant) and an air-purifying respirator. Level B includes a hooded garment and a self-contained breathing apparatus or supplied air-line respirator. Level A includes a fully encapsulating suit and the same respiratory protection as used in Level B.

TYPES OF DECONTAMINATION

Decontamination can be accomplished by:

- Physically removing the contaminants
- Chemically removing the contaminants
- Rinsing off contaminants
- Disinfecting and sterilizing (infectious materials) PPE
- A combination of the above methods

Physical Removal

Gross contamination can often be removed by physical means involving dislodging/displacement, rinsing, wiping off, and evaporation:

- Loose contaminants: Dusts and vapors can be removed with water or a liquid rinse.
- Adhering contaminants: Removal methods include scraping, brushing, and wiping.
- Removal can be enhanced through solidifying, freezing, absorption, or melting, but these are not very common in hazardous-waste work.
- Volatile liquids: These can be removed by evaporation followed by a water rinse. Evaporation can be enhanced by using steam jets. (Jet streams are never used on personnel.)

Chemical Removal

Physical removal should be followed by a wash/rinse process using cleaning solutions that utilize one or more of the following:

- Dissolving contaminants: Organic solvents include alcohols, ethers, ketones, aromatics, straight-chain alkanes, and common petroleum products.
- Surfactants: These reduce adhesion forces between contaminants and the surface being cleaned and prevent redeposit of the contaminants. Household detergents are among the most common surfactants.
- Solidification: This is used for liquid or gel contaminants and involves moisture removal through the use of absorbents (grounded clay or powdered lime),

chemical reactions via polymerization catalysts and chemical reagents; and freezing.

- Rinsing: This removes contaminants through dilution.

From a health and safety standpoint, there are two key questions that should be asked and answered: 1. Is the decontamination method effective for the specific substance? 2. Does the decontamination method itself pose any hazards?

Rinsing Off Contaminants

A soap-and-water solution is most frequently used to remove contaminants from personal protective and other equipment. Once washing occurs, rinsing simply removes the contaminant. Rinsing is an important procedure. Multiple rinses with clean solutions will generally remove more contaminants than a single rinse with the same volume of solution.

Sanitizing of Personal Protective Equipment:

Respirators, reusable protective clothing, and other personal articles not only must be decontaminated before being reused but also sanitized. The inside of masks and clothing becomes soiled due to exhalation, body oils, and perspiration. The manufacturer's instructions should be used to sanitize the respirator mask. If practical, protective clothing should be machine-washed after a thorough decontamination; otherwise it must be cleaned by hand.

Figure 9.4 This equipment is used to clean respiratory protective equipment.

Equipment Needs

Decontamination efforts require that equipment for the task be set up in advance so that in the event that personnel become contaminated, they can immediately be cleaned. Some of the equipment used includes:

- Cans for contaminated wash and rinse solutions
- Plastic sheeting for containing and collecting contaminated wash and rinse solutions spilled
- Shower facilities
- Soap, wash cloths, towels for personnel
- Lockers for clean clothing, personal item storage

The following are recommended for heavy equipment and vehicle decontamination:

- Tanks for temporary storage and treatment of contaminated wash and rinse solutions
- Brushes
- Wash solutions
- Rinse solutions to remove contaminants and contaminated wash solutions
- Pressurized sprayers for washing and rinsing (garden sprayers)
- Curtains to contain splashes from pressurized sprays
- Brushes, rods, and shovels for dislodging contaminants caught in tires and the underside of vehicles and equipment
- Containers to hold contaminants
- Wash and rinse buckets
- Brooms and brushes for cleaning inside vehicles and equipment
- Containers for storage and disposal of contaminated wash and rinse solutions, damaged or heavily contaminated parts, and equipment to be discarded

All decontamination workers are working in a contaminated area or with contaminated materials and therefore must also be decontaminated before entering the (clean) support zone. Table 9.3 depicts some safety procedures for decontamination.

Proper Disposal

All equipment used for decontamination must be decontaminated and/or disposed of properly. Buckets, brushes, clothing, tools, and other contaminated equipment should be collected, placed in containers, and labeled. All spent solutions and wash water should be collected and disposed of properly. Clothing and equipment that is

Table 9.3 Safety procedures for decontamination

Ensure decontamination solutions are compatible with the substances being removed to prevent any reaction
Station adequate staff to assist each worker through the decontamination line
If plastic sheeting or other slippery surfaces may be encountered, gripper decals or the like can be used to reduce the likelihood of slips, trips and falls
Provide hand-holds at stations where boots and/or covers are washed or removed
Ensure all areas are cleaned
Shower and change rooms provided outside of a contaminated area must meet the requirements of OSHA 29 CFR 1910.141

not completely decontaminated should be placed in plastic bags, pending further decontamination or disposal.

Disposal of Contaminated Materials

All materials and equipment used for decontamination must be disposed of properly. Clothing, tools, buckets, brushes, and all other equipment that is contaminated must be secured in drums or other containers and labeled. Clothing not completely decontaminated on-site should be secured in plastic bags before being removed from the site.

Figure 9.5 This vehicle and heavy equipment decontamination station was established for equipment used after the devastation in New York City after September 11.

Figure 9.6 The decontamination station is shown with a vehicle entering.

Figure 9.7 This worker is carrying contaminated materials in bags to the proper location. This prevents spreading contamination.

Contaminated wash and rinse solutions should be contained by using step-in containers (for example, child's wading pool) to hold spent solutions. Another containment method is to dig a trench about four inches deep and line it with plastic. In both cases the spent solutions are transferred to drums, which are labeled and disposed of with other substances on-site.

PERSONAL PROTECTION

Decontamination workers will initially come in contact with personnel and equipment leaving the exclusion zone and will require more protection from contaminants than decontamination workers who are assigned to the last station in the decontamination line. The level of protection required will vary with the type of decontamination equipment used and the contaminant involved.

Preliminary Concerns

The initial decontamination plan assumes all personnel and equipment leaving the exclusion zone (area of potential contamination) are grossly contaminated. A system is then set up to wash and rinse, at least once, all the personal protective equipment worn (with the exception of disposable garments). This is done in combination with a sequential doffing of equipment, starting at the first station with the most heavily contaminated item and progressing to the last station with the least contaminated article. Each piece of clothing or operation requires a separate station.

Figure 9.8 Watering down a dusty area

The spread of contaminants during the washing/doffing process is further reduced by separating each decontamination station by a minimum of three feet, if possible. Ideally, contamination should decrease as a person moves from one station to another further along in the line.

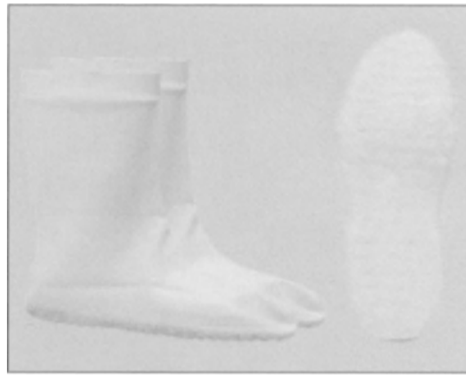


Figure 9.9 Boots such as these are disposable and can be worn over your shoes to protect your personal shoes.

While planning site operations, methods should be developed to prevent the contamination of people and equipment. For example, using remote sampling techniques, not opening containers by hand, bagging monitoring instruments, using drum grapplers, watering down dusty areas, and not walking through areas of obvious contamination would reduce the probability of becoming contaminated and require a less elaborate decontamination procedure.

The initial decontamination plan is based on a worst-case situation (if no information is available about the incident). Specific conditions at the site are then evaluated, including:

- Type of contaminant
- The amount of contamination
- Levels of protection required
- Type of protective clothing worn

The initial system is then modified, eliminating unnecessary stations or otherwise adapting it to site conditions. For instance, the initial plan might require a complete wash and rinse of chemical protective garments. If disposable garments are worn, the wash/rinse step could be omitted. Wearing disposable boot covers and gloves could eliminate washing and rinsing both gloves and disposable boots and reduce the number of stations needed.

An area within the contamination reduction (warm) zone (CRZ) is designated the contamination reduction corridor (CRC). The CRC controls access into and out of the exclusion (hot) zone and confines personnel decontamination activities to a limited area. The size of the corridor depends on the number of stations in the decontamination procedure, overall dimensions of work control zones, and the probability of personnel contact. Swipe tests may help determine the type and quantity of surface contaminants.

Figure 9.10 Swipe testing is being done in this area by these workers.

Level of Protection

The level of protection and specific pieces of clothing worn determine, on a preliminary basis, the layout of the decontamination line. Each level of protection incorporates different problems in decontamination and doffing of the equipment. For example: decontamination of the harness straps is difficult. A butyl rubber apron worn over the harness makes decontamination easier. Clothing variations and different levels of protection may require adding or deleting stations in the original decontamination procedure or plan.

The level of protection worn by decontamination workers is determined by the following:

- Expected or visible contamination on workers
- Type of contaminant and associated respiratory and skin hazards
- Total vapor/gas concentrations in the contamination reduction corridor (CRC)
- Particulates and specific inorganic or organic vapors in the CRC
- Results of swipe tests
- The presence (or suspected presence) of highly toxic or skin-destructive materials

Work Function

The work each person is assigned determines the potential for contact with various hazardous materials. In turn, this indicates the layout of the decontamination line.

Site visitors, observers, members of the media, operators of air samplers, or other individuals in the exclusion zone performing tasks that will not bring them in contact with contaminants may not need, for example, to have their garments washed and rinsed. Others in the exclusion zone with a potential for direct contact with the hazardous material will require a more thorough decontamination. Different decontamination lines could be set up for different job functions, or certain stations in a line could be omitted for personnel performing certain tasks.

Location of Contamination

Contamination on the upper areas of protective clothing poses a great risk to the worker because volatile compounds may generate a hazardous breathing concentration both for the worker and for the decontamination personnel. There is also an increased probability of contact with skin when doffing the upper part of clothing. Each situation will need to be evaluated prior to establishing a decontamination plan.

Reasons for Leaving Site

The reason for leaving the exclusion zone also determines the need and extent of decontamination. A worker leaving to pick up or drop off tools or instruments and immediately returning may not require decontamination. A worker leaving to get a new air cylinder or change a respirator or canisters, however, may require some degree of decontamination. Individuals departing the warm zone for a break, lunch, end of day, etc., must be thoroughly decontaminated.

Establishment of Procedures

It is important to establish a set of standard operating procedures that minimize contact with hazardous substances, thereby maximizing worker protection. For example, properly donning PPE will minimize the potential inhalation or absorption of the contaminated materials. Other SOP's include:

- Inspecting PPE to ensure it is in proper condition before each use
- Completely closing zippers, buttons, and snaps
- Tucking both inner and outer gloves under the sleeves
- Tucking boots under the legs of outer clothing
- Wearing hoods, if not attached, outside the collar
- Taping all seams to prevent contaminants from running inside gloves, boots, and jackets

Once decontamination procedures have been established, all personnel requiring decontamination must be given precise instructions (and practice, if necessary). Compliance must be frequently checked to ensure that it is being done correctly. The time it takes for decontamination must be ascertained. Personnel wearing breathing apparatus must leave their work area with sufficient air supply to walk to the CRC and go through decontamination.

DECONTAMINATION DURING MEDICAL EMERGENCIES

Part of overall planning for incident response or site management is preparing for medical emergencies. The plan should provide for:

- Some team members who are fully trained and certified in first aid and CPR available at all times while workers are present at the site
- Phone numbers for medical, toxicology, safety, and health professionals posted in a conspicuous place
- Arrangements with the nearest medical facility for transportation and treatment of injured and personnel suffering from exposure to chemicals
- Consultation services with a toxicologist
- Strategically located emergency eye washes, showers, and wash stations
- Fully stocked first aid kits, blankets, stretcher, and oxygen (if personnel are trained to use it)

In addition, the plan should have established methods for decontaminating personnel with medical problems and injuries. There is the possibility that the decontamination may aggravate or cause more serious health effects. If prompt lifesaving first aid and medical treatment is required, decontamination procedures should be omitted. Whenever possible, response personnel should accompany contaminated victims to the medical facility to give advice on matters involving decontamination, if needed.

Physical Injury

Physical injuries can range from a sprained ankle to a compound fracture, from a minor cut to massive bleeding. Depending on the seriousness of the injury, treatment may be given at the site by trained personnel. For more serious injuries, additional assistance may be required at the site or the victim may have to be treated at a medical facility.

Partial and Full Decontamination

Though it may not be feasible for workers to remove all contaminated protective gear each time they take a break, it is necessary that enough decontamination take place to prevent contamination from spreading into any of the clean areas at the site. More importantly, workers must clean their hands, feet, face, or other exposed body

Figure 9.11 First aid kits should be fully stocked and checked periodically.

Figure 9.12 Ambulance crew loads patient into ambulance for trip to hospital.

areas so they don't inadvertently ingest or spread the contamination to normally protected parts of their bodies.

At the completion of the work shift, workers typically return to their living quarters or a personal home, which has the potential to expose other people and facilities to secondary contamination. To prevent this risk, full decontamination must take place to remove all contamination prior to leaving the work site.

Decontamination allows employees to safely remove contaminated protective gear within a dirty area without contaminating their personal clothing or work uniform. In some cases they proceed to clean facilities, such as a shower room, to remove traces of contamination. Within the clean area they will also don their street clothing before going to their living quarters or to other clean areas. The intent of this process is to keep the dirty work clothes in dirty zones and the clean clothing in clean areas. The following are examples of decontamination procedures:

- Prior to lunch, remove gloves and clean hands with waterless hand cleaner. If available, use soap and water.
- Contaminated clothing must be removed carefully to avoid secondary skin exposure. For example, hands can become exposed from handling boots and other gear if inner gloves are taken off prematurely.
- At shift's end, proceed to assigned decontamination area. Decontamination takes place in a sequence of segregated areas.
- All outer clothing will be removed in the designated dirty area. This includes outer gloves, boots, rain gear, and hard hats. Serviceable outer gear will be decontaminated and reused when necessary.
- Once outer gear is removed, proceed to an area to remove respiratory protection, and place it in a designated container.
- Next, proceed to an area to remove the inner suit and gloves. These are to be disposed of in the proper container.
- Next, move into the shower room. Wash and dry if necessary. Pay particular attention to areas of the body that have hair.
- Change into street clothing and shoes that were left in the clean area at the start of the work shift.

Figure 9.13 Here a worker is using waterless hand cleaner before he leaves the work site.

Decontamination procedures will vary from site to site according to the contaminants present, categories of tasks assigned to workers, and the available facilities. The essence of decontamination procedures is to remove all contamination from work clothing and prevent direct skin contact and secondary contamination of outer garments and clean areas.

Figure 9.14 These are outer gloves. This type is longer in the sleeve.

Persistent Contamination

In some instances, clothing and equipment will become contaminated with substances that cannot be removed by normal decontamination procedures. A solvent may be used to remove such contamination from equipment if it does not destroy the protective material. If persistent contamination is expected, disposable garments should be used. Testing for persistent contamination of protective clothing and appropriate decontamination must be done by qualified laboratory personnel.

Table 9.4 outlines a decontamination plan. Table 9.5 highlights the various decontamination methods as a review. Table 9.6 gives a sample decontamination layout.

Figure 9.15 These inner gloves can also be worn as outer gloves. If worn as an outer glove, I recommend double gloves. **[I recommend? Usually don't use 1st person? Does I = author?]**

Table 9.4 Decontamination plan

Decontamination Plan

(Incorporate Into the Site Safety Plan before any Field Work Begins)

- Decontamination Station Layout
- Equipment Needed
- Appropriate Decontamination Methods
- Procedures to Prevent Spread of Contamination
- Minimization of Contact with Contaminated Clothing/Equipment by the Decontamination Worker
- Disposal of Non-Decontaminated Clothing/Equipment

The plan should be revised whenever the PPE changes, conditions change or site hazards are reassessed.

Table 9.5 Decontamination methods

ALL Personal Clothing, Equipment, and Samples Leaving the Exclusion Zone MUST be decontaminated.

Physical Removal

- Loose Contaminants
  - Water rinse, using pressurized or gravity flow
  - Application of anti-static solutions
- Adhering Contaminants
  - Scraping, brushing, wiping
  - Enhance removal by solidifying, freezing, absorption (kitty litter) melting
- Volatile Liquids

  Warning: Use of this method may be dangerous to your health
  - Evaporation followed by water rinse
  - Enhance removal with steam jets

Chemical Removal

- Dissolving Contaminants
  - Solvent must be chemically compatible with equipment being decontaminated
  - Care must be taken when selecting, using and disposing of any organic solvents
  - Flammability, toxicity concerns

Table 9.6 Decontamination layout

Station One: Hard Hat removal

Station Two: Tool and Equipment Drop

Station Three: Wash and Rinse Gloves

Station Four Tape Removal:
Remove tape around boots and gloves and deposit in container with plastic liner.
Equipment: Container (20-30 gallons)
Plastic liners

Station Five (5) Boot Cover Removal:
Remove boot covers and deposit in container with plastic liner.
Equipment: Container (30-50 gallons)
Plastic liners
Bench or stool

Station Six Outer Glove Removal:
Remove outer gloves and deposit in container with plastic liner.
Equipment: Container (20-30 gallons)
Plastic liners

Station Seven Suit/Safety Boot Wash:
Thoroughly wash chemical resistant splash suit, gloves and boots. Scrub suit and boots with long-handle, soft-bristle scrub brush and copious amounts of decontaminantion solution or detergent/water. Repeat as many times as necessary.
Equipment: Container (30-50 gallons)
Decontamination solution
Detergent/water
Two-three (2-3) long-handle, soft-bristle scrub brushes

Station Eight Suit/Safety Boot Rinse:
Rinse off decontamination solution or detergent/water using copious amounts of water. Repeat as many times as necessary.
Equipment: Container (30-50 gallons)
High-pressure spray unit
Water
Two-three (2-3) long-handle, soft-bristle scrub brushes

Stations Nine through twelve are washing and rinse stations.

Station Thirteen Inner Glove Rinse:
Rinse with water. Repeat as many times as necessary.
Equipment: Water
Basin or bucket
Small table

(continues)

Table 9.6 Decontamination layout (*continued*)

Station Fourteen Face piece Removal:
Remove face piece. Deposit in container with plastic liner. Avoid touching face with fingers.
Equipment: Container (30-50 gallons)
Plastic liners

Station Fifteen Inner Glove Removal:
Remove inner gloves and deposit in container with plastic liner.
Equipment: Container (20-30 gallons)
Plastic liners

Station Sixteen Inner Clothing Removal:
Remove clothing soaked with perspiration. Place in container with plastic liner. Do not wear inner clothing off-site since there is a possibility that small amounts of contaminants might have been transferred in removing the fully encapsulated suit.
Equipment: Container (30-50 gallons)
Plastic liners

Station Seventeen Field Wash:
Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.
Equipment: Water
Soap
Small table
Basin or bucket
Field showers
Towels

Figure 9.16 Worker is having his boot washed. The feet and hands are the most contaminated places on workers.

Figure 9.17 This shows a typical decontamination station layout.

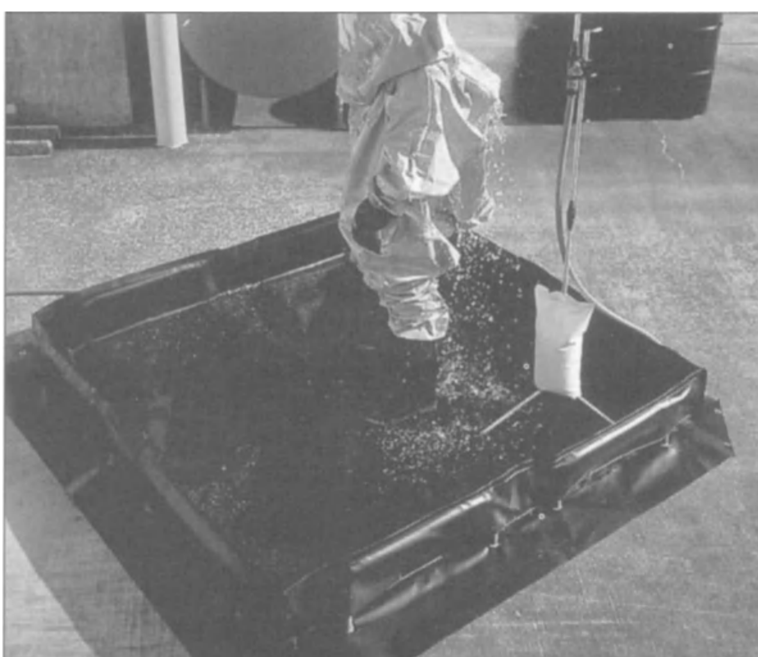


Figure 9.18 This worker uses a shower to self decontaminate.

Figure 9.19 This decontamination station has portable hoses connected inside, so that this can be used in an emergency situation, or in the hot or cold weather, to keep personnel inside.

SUMMARY

As we have discussed in this chapter, the prevention and control of contamination are extremely important to the entire hazardous-waste-operations assignment. There is not a reliable technique to immediately determine the effectiveness of decontamination. In some cases, an estimation of effectiveness can be made by visual observation. An exact determination of effectiveness can be gained by sending the equipment for analysis to test for the presence of contamination. Another way is to analyze the final rinse water for presence of contaminants; however, this will take a few days to get results.

10

RESPIRATORY PROTECTION

SELECTION OF RESPIRATORY EQUIPMENT

Respiratory protection is of primary importance, as the lungs present the body's greatest exposed surface area. Respiratory protective devices (respirators) consist of a face piece connected to an air or oxygen source. The three major categories of respirators differ with respect to the air or oxygen source:

- A self-contained breathing apparatus (SCBA) supplies air from a source carried by the user
- An air-line respirator (ALR) supplies air from a source located some distance away that is connected to the user by a hose, sometimes called an umbilical cord.
- An air-purifying respirator (APR) enables the user to inhale "purified" ambient air

Figure 10.1 An air purifying respirator is shown in the photo above.

Because they both supply air to the user, ALRs and SCBAs are sometimes categorized together as supplied-air respirators. Table 10.1 lists the relative advantages and disadvantages of SCBA, ALR, and air-purifying respirators.

Respirators are further differentiated by the type of air flow supplied to the face piece:

- Negative-pressure respirators (also referred to as demand respirators) draw air into the face piece via the negative pressure created by user inhalation. The disadvantage of demand respirators is that, if any leaks develop in the system (e.g., a crack in the hose or an ill-fitted mask or face piece), the user will draw in contaminated air during inhalation.
- Positive-pressure respirators (also referred to as pressure-demand respirators) maintain a slight positive pressure in the face piece during both inhalation and exhalation. A pressure regulator and an exhalation valve on the mask maintain the mask's positive pressure at all times. If a leak develops, the regulator sends a continuous flow of clean air into the face piece, preventing penetration of contaminated ambient air. Only positive-pressure respirators are recommended for work at hazardous-waste sites.
- Continuous-flow respirators send a continuous stream of

Figure 10.2 This picture shows a self contained breathing apparatus

Figure 10.3 This shows a worker attached to an airline respirator.

Table 10.1 Advantages and disadvantages of air-purifying respirators

TYPE OF RESPIRATOR	ADVANTAGES	DISADVANTAGES
ATMOSPHERE-SUPPLYING Self-Contained Breathing Apparatus (SCBA)	• Provides the highest available level of protection against airborne contaminants and oxygen deficiency. • Provides the high available level of protection under strenuous work conditions.	• Bulky, heavy (up to 35 pounds). • Finite air supply limits work duration. • May impair movement in confined spaces.
Positive-Pressure Supplied-Air Respirator ({SAR} also called airline respirator)	• Enables longer work periods than an SCBA. • Less bulky and heavy than an SCBA. SAR equipment weighs less than 5 pounds (or around 15 pounds if escape SCBA protection is included). • Protects against most airborne contaminants.	• Not approved for use in atmospheres immediately dangerous to life or health (IDLH) or in oxygen-deficient atmospheres unless equipped with an emergency egress unit such as an escape-only SCBA that can provide immediate emergency respiratory protection in case of air-line failure. • Impairs mobility. • MSHA/NIOSH certification limits hose length to 300 feet (90 meters). • As the length of the hose is increased, the minimum approved air flow may not be delivered at the face piece. • Air line is vulnerable to damage, chemical contamination and degradation. Decontamination of hoses may be difficult. • Worker must retrace steps to leave work area. • Requires supervision/monitoring of the air supply line.
AIR-PURIFYING Air-Purifying Respirator (including powered air-purifying respirators {PAPRs})	• Enhances mobility. • Lighter in weight than an SCBA. • Generally weighs 2 pounds (1 kg) or less (except for PAPRs).	• Cannot be used in IDLH or oxygen-deficient atmospheres (less than 19.5 percent oxygen at sea level). • Limited duration of protection. May be hard to gauge safe operating time in field conditions. • Only protects against specific chemicals and up to specific concentrations. • Use requires monitoring of contaminant and oxygen levels. • Can only be used (1) against gas and vapor contaminants with adequate warning properties, or (2) for specific gases or vapors provided that the service is known and a safety factor are applied or if the unit has an ESLI (end-of-service-life indicator).

air into the face piece at all times. Continuous air flow prevents infiltration by ambient air but exhausts the air supply much more rapidly than positive- or negative-pressure respirators.

Figure 10.4 This is a full face respirator.

Several different types of face pieces are available for the various types of respirators.

- Full face pieces cover the face from the hairline to below the chin. They are recommended for use on controlled sites since they provide eye as well as respiratory protection.
- Half masks cover the face from below the chin to over the nose. They can be used when the airborne contaminants have been identified and are judged unlikely to irritate the eyes.
- Quarter masks cover the nose and mouth but not the chin. Their face-piece-to-face seal is not as good as half- and full-face pieces. NIOSH does not recommend their use on hazardous-waste sites, but OSHA does accept them for industrial use.

Federal regulations require the use of approved respirators. Approval numbers are clearly written on all approved respiratory equipment; however, not all respiratory

Figure 10.5 This photo depicts a half face respirator.

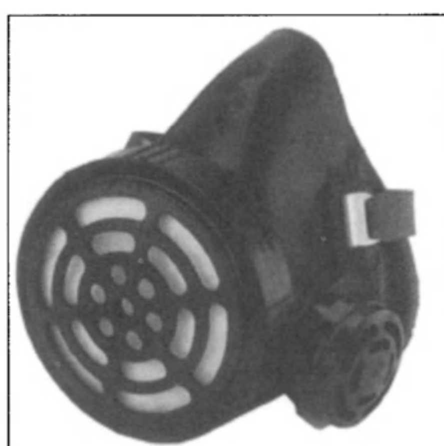


Figure 10.6 This is a quarter face mask.

equipment that is marketed is approved. Respirators are tested by NIOSH and, if they pass the OSHA requirements specified in 30 CFR II, are jointly approved by the Mine Safety and Health Administration (MSHA) and NIOSH. Testing procedures are described in 30 CFR II. Periodically, NIOSH publishes a list of all approved respirators and respiratory components.

Air-Purifying Respirators

Air-purifying respirators consist of a face piece and an air-purifying device, which is a removable component of the face piece, or an air-purifying apparatus worn on a body harness and attached to the face piece by a corrugated breathing hose. Air-purifying respirators selectively remove specific airborne contaminants (particulates, gases, vapors, and fumes) from ambient air by filtration, absorption, or adsorption. They are approved for use in atmospheres containing specific chemicals up to designated concentrations and not for IDLH (Immediately Dangerous to Life and Health) atmospheres. Air-purifying respirators have limited use in remedial actions involving hazardous materials and can be used only when the ambient atmosphere contains sufficient oxygen (19.5 percent) to support life at high work rates.

Figure 10.7 This shows a respirator filter.

Air-purifying respirators usually operate only in the negative-pressure mode. There are blower-powered devices that maintain a positive face-piece pressure, but they generally remove only dust, fumes, and particulates and not gases or vapors.

Three types of purifying devices exist: (1) particulate filters, which remove particulates; (2) cartridges and canisters, which contain sorbents for specific chemicals, gases, and vapors, and (3) combination devices. Their efficiencies vary considerably even for closely related materials.

Cartridges attach directly to the face piece. The larger-volume canisters attach to the chin of the face piece or are carried with a harness and attach to the face piece by a breathing tube. "Single" cartridges and canisters remove only one chemical or one class of chemical. There are designated maximum concentration limits above which they should not be used (Title 30 CFR Part II, Section 150). Combination canisters and cartridges (also known as Type N, all-service, universal, or all-purpose canisters)

Figure 10.8 This photo shows a respirator cartridge.

contain layers of different sorbent materials and remove multiple chemicals or multiple classes of chemicals from the ambient air. Though approved against more than one substance, these canisters are tested independently against single substances. However, their effectiveness against two or more substances together has not been demonstrated.

Filters may also be combined with cartridges to provide additional protection against particulates. A number of standard cartridges and canisters are commercially available; they are color-coded to indicate the general chemicals or classes of chemicals against which they are effective.

NIOSH has granted approvals for complete assemblies of air-purifying respirators (i.e., gas mask with canister or cartridge) against a limited number of specific chemicals, including ammonia, chlorine, formaldehyde, hydrogen chloride, methyl iodide, monomethylamine, and sulfur dioxide. Certain respirators have received special approval against vinyl chloride under carefully controlled conditions, while others are approved against carbon monoxide. If requested, NIOSH will test and grant approvals of specific air-purifying respirators against individual chemicals.

Respirators should be used only against those substances for which they have been approved. Use of a sorbent shall not be allowed when there is reason to suspect that it does not provide adequate sorption efficiency against a specific contaminant. In addition, note that approval testing is performed at a given temperature over a narrow range of flow rates and relative humidity. Thus, protection may be comprised in nonstandard conditions. The assembly that has been approved by NIOSH to protect against organic vapors is tested against only a single challenge substance, carbon tetrachloride. Therefore, its effectiveness for protecting against other vapors has not been demonstrated.

Chemical sorbent cartridges and canisters have an expiration date. They may be used up to that date so long as they were not opened previously. Once opened, they begin to absorb humidity and air contaminants whether or not they are in use, and their efficiency and service life decrease. Discard cartridges after use.

Where a canister or cartridge is being used against gases or vapors, the appropriate device shall be used only if the chemical(s) have "adequate warning properties" (30 CFR II. Section 150). The regulation also prohibits the use of air-purifying respirators against organic vapors that have poor warning properties. A substance is considered to have adequate warning properties when:

- Its odor, taste, or irritant effects are detectable and persistent at concentrations below the permissible exposure limit (PEL)
- Its odor or irritation threshold is somewhat above the permissible exposure limit, but no ceiling limits exist and no serious or irreversible health effects occur within this concentration range

A substance is considered to have poor warning properties when:

- Its odor or irritation threshold is three or more times greater than the permissible exposure limit

These warning properties are essential to the safe use of air-purifying respirators, since they allow detection of contaminant breakthrough should it occur. While warning properties are not foolproof, because they rely on human senses, they do provide some indication of possible sorbent exhaustion, poor face-piece fit, or other malfunctions.

Some key questions to ask when considering use of an air-purifying respirator are:

- Does the ambient atmosphere contain at least 19.5 percent oxygen? If not, do not use an air-purifying respirator.
- Is the atmosphere immediately dangerous to life or health? If so, do not use an air-purifying respirator.
- Is a cartridge, canister, or filter available that has been approved for the chemical or chemicals present in the atmosphere? If not, do not use an air-purifying respirator.
- Is the ambient-chemical concentration below the designated maximum use concentration? If not, do not use an air-purifying respirator.
- Is the ambient air monitored periodically to ensure that workers are not being exposed to dangerous levels of toxic chemicals? If not, institute such monitoring.
- Are there any dangerous conditions that could change without warning? If so, equip the workers with escape SCBAs.
- Could the contaminants cause skin or eye irritation or penetrate the skin? If so, use a full-face piece on the respirator.
- Does the respirator face piece provide a good seal against the user's face as demonstrated by fit testing? Do not use respirators that do not provide a good face-to-face-piece seal.

The type of equipment used and the overall level of protection should be reevaluated periodically as the amount of information about the site increases and as workers are required to perform different tasks. Personnel should be able to upgrade their level of protection if, after discussion with the site safety officer, they feel it is necessary and the site safety officer approves. Any downgrading of protection levels must also be approved by the site safety officer.

Reasons to upgrade protection include:

- Known or suspected presence of dermal chemicals
- Occurrence or likely occurrence of detonation or gas emissions
- Change in work task that will increase contact or potential contact with hazardous materials
- Request of the individual performing the task

Some reasons to downgrade protection might include the following:

- New information indicating that the situation is less hazardous than originally thought
- Change in site conditions that decrease the hazard
- Change in work tasks that will reduce contact with hazardous substances

Factors that Preclude APR Use

There are situations that may preclude the wearing of air-purifying respirators. Some of those circumstances include:

- Oxygen deficiency
- IDLH concentrations
- Entry into an unventilated or confined area
- Firefighting
- Situation requires a protection factor greater than 50
- Presence of unidentified contaminants
- Contaminant concentrations unknown or exceeding designated maximum use concentration
- Identified chemicals have inadequate or no warning properties
- One or more airborne contaminants that may be absorbed is shock- sensitive
- Presence of two or more incompatible contaminants onsite that might react in the cartridge or canister to produce a toxic or hazardous condition

Protection Factors

The protection factor, described by a number, denotes the overall level of protection provided by the respirator. The protection factor is determined by the fit and, with air-purifying respirators, by the filtering ability of the respirator. The number indicates the relative difference in concentrations of substances outside and inside the face piece that can be maintained by the respirator. For example, the protection factor for full-face-piece air-purifying respirators is 100, according to the American National Standards Institute (ANSI). This means, theoretically, that workers wearing these respirators should be protected in atmospheres containing chemicals at concentrations that are 100 times higher than their safe levels. Protection factors are determined by quantitative analytical tests. The protection factors for various types of SCBA, air-line, and air-purifying respirators are listed in Table 10.2.

Table 10.2 Protection Factors

Respirator Type	Protection Factor
Half face respirator	50
Full face respirator	100
Airline respirator	1,000
SCBA	10,000

To determine whether a SCBA or ALR respirator provides adequate protection in a given situation, multiply the protection factor by the threshold limit value (TLV) or permissible exposure limit (PEL) for the chemical(s) in the atmosphere.

$$PF \times TLV \text{ (or PEL) ambient concentration}$$

Adequate protection is provided against a particular chemical if the product is greater than the measured ambient concentration of the chemical. For air-purifying respirators, the maximum safe-use concentration for specific chemicals is designated on the respirator. However, bear in mind that a respirator's protection factor can be compromised in several situations, most notably (1) if a worker has a high respiration rate or (2) if the ambient temperature is high or low.

When a worker's respiration rate exceeds 67 liters per minute, many positive-pressure respirators will not maintain positive pressure during peak inhalation. This "inboard" face-piece leakage, as it is called, occurs in both ALR and SCBA respirators. Also, at high work rates exhalation valves may leak. Consequently, positive-pressure respirators working at 67 liters per minute (or greater) offer no greater protection than a similarly equipped negative-pressure respirator. In terms of the numerical protection factor, this is a reduction from 10,000 to approximately 50. (Actual protection reduction is difficult to estimate and varies from unit to unit.)

A similar reduction in the protection factor (10,000 to 50) may be occasioned by high or low ambient temperatures. As a general precaution, consider that protection factors may decrease at temperatures below 60° F. Note that the temperature inside a fully encapsulated suit, within which a SCBA might be worn, may exceed 90° F.

Air-Line Respirators (ALRs)

Air-line respirators (or supplied-air respirators) supply air, never oxygen, to a face piece via a supply line from a stationary source. ALRs are available in

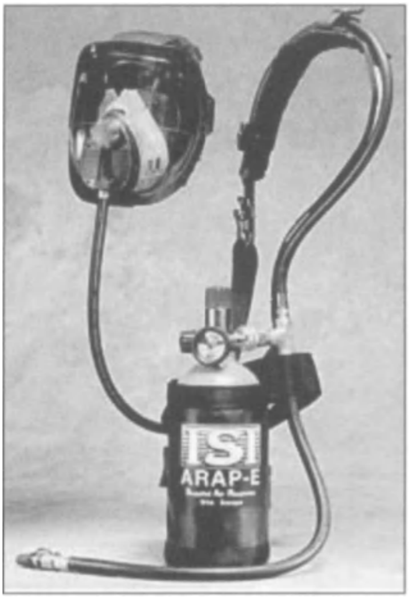


Figure 10.9 This picture shows an escape breathing apparatus.

positive-pressure, negative-pressure, and continuous-flow systems. Positive-pressure and continuous-flow ALRs with escape provisions provide the highest level of protection (among ALRs) and are the only ALRs recommended for use in remedial actions involving hazardous materials. ALRs are not approved for entry into IDLH atmospheres unless the apparatus is equipped with an emergency bailout bottle or workers also wear an escape SCBA.

The air source for air-line respirators may be a compressor, which purifies and pumps ambient air to the face piece, or compressed-air cylinders. ALRs suitable for use with compressed-air cylinders are classified as Type C supplied-air respirators. All ALR couplings must be incompatible with the outlets of other gas systems used onsite to prevent a worker from connecting to a hazardous compressed-gas source. This incompatibility is generally standardized.

ALRs enable longer work periods than SCBAs and are less bulky. However, the air-line hose impairs worker mobility and requires workers to retrace their steps when leaving the area. Also, the air-line hose is vulnerable to puncture from rough or sharp surfaces, chemical permeation, and damage by heavy equipment and obstruction from falling objects, drums, etc. To maintain safe conditions, all such hazards should be removed prior to use. When in use, air lines should be kept as short as possible and other workers and vehicles should be kept away from them.

Figure 10.10 Airline respirator hose is shown above. The airline hose is restricted to no more than three hundred feet by OSHA.

The use of air compressors as the air source for an ALR at a hazardous-waste site is severely limited by the same concern that requires workers to wear respirators: the questionable quality of the ambient air. Onsite compressor use is recommended only when contaminants can be identified and readily removed by sorbents in the compressor's air-purification system. However, even in these conditions a purification system shares the same constraints as an air-purifying respirator: i.e., effective filters and/or sorbents capable of removing these contaminants must be available.

Some of the key issues to consider with ALR use are:

- Is the atmosphere immediately dangerous to life or health? If so, use an ALR/SCBA combination or SCBA.
- Will the hose significantly impair worker mobility? If so, modify the task or use other respiratory protection.
- Is there a danger of the air-line hose being damaged, obstructed (e.g., by heavy equipment, falling drums, rough terrain, or sharp objects), or permeated and/or degraded by chemicals? If so, remove the hazardous chemicals or use other respiratory protection.
- If a compressor is the air source, is it possible for airborne contaminants to enter the air system? If so, have the contaminants been identified and are efficient filters and/or sorbents available that are capable of removing those contaminants? If not, use cylinders as the air source or use another form of respiratory protection.
- Can other workers and vehicles be kept away from the area where the line has been laid? If not, consider another form of respiratory protection.

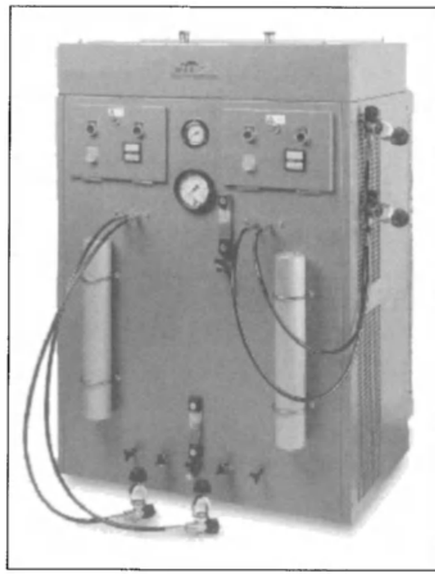


Figure 10.11 A breathing air compressor is needed to fill cylinders with Grade D breathing air.

Self-Contained Breathing Apparatus (SCBA)

A self-contained breathing apparatus (SCBA) consists of a face piece connected by a hose and a regulator to an air source, compressed air, compressed oxygen, or an oxygen-generating chemical carried by the wearer. SCBAs are the only respirators approved for entry into IDLH (immediately dangerous to life and health) atmospheres.

Because SCBAs use an independent rather than an ambient air source, they offer protection against most types and levels of airborne contaminants. However, the duration of the air supply is limited, based on the amount of air and the rate of air consumption, and is an important planning factor in SCBA use. Also, SCBAs are bulky and heavy; they increase the likelihood of heat stress and may impair movement in

Table 10.3 Types of Self-Contained Breathing Apparatus

TYPE	DESCRIPTION	ADVANTAGES	DISADVANTAGES	COMMENTS
ENTRY-AND-ESCAPE SCBA Open-Circuit SCBA	Supplies clean air to the wearer from a cylinder. Wearer exhales air directly to the atmosphere.	Operated in a positive-pressure mode, open-circuit SCBAs provide the highest respiratory protection currently available. A warning alarm signals when only 20 to 25 percent of the air supply remains.	Shorter operating time (30 to 60 minutes) and heavier weight (up to 35 pounds [13.6 kg]) than a closed-circuit SCBA.	The 30- to 60-minute operating time may vary depending on the size of the air tank and the work rate of the individual.
Closed-Circuit SCBA [Rebreather]	These devices recycle exhaled gases [CO_2, O_2, and nitrogen] by removing CO_2 with an alkaline scrubber and replenishing the consumed oxygen with oxygen from a liquid or gaseous source.	Longer operating time (up to 4 hours), and lighter weight (21 to 30 lbs [9.5 to 13.6 kg]) than open-circuit apparatus. A warning alarm signals when only 20 to 25 percent of the oxygen supply remains. Oxygen supply is depleted before the CO_2 sorbent scrubber supply, thereby protecting the wearer from CO_2 breakthrough.	At very cold temperatures, scrubber efficiency may be reduced and CO_2 breakthrough may occur. Units retain the heat normally exchanged in exhalation and generate heat in the CO_2 scrubbing operations, adding to the danger of heat stress. Auxiliary cooling devices may be required. When worn outside an encapsulating suit, the breathing bag may be permeated by chemicals, contaminating the breathing apparatus and the respirable	Positive-pressure closed-circuit SCBAs offer substantially more protection than negative-pressure units, which are not recommended on hazardous- waste sites. While these devices may be certified as closed-circuit SCBAs, there may be limitations due to certification procedures currently defined in 30 CFR Part 11

Table 10.3 Types of Self-Contained Breathing Apparatus (*continued*)

TYPE	DESCRIPTION	ADVANTAGES	DISADVANTAGES	COMMENTS
			air. Decontamination of the breathing bag may be difficult.	
ESCAPE-ONLY SCBA	Supplies clean air to the wearer from either an air cylinder or from an oxygen-generating chemical. Approved for escape purposes only.	Lightweight (10 pounds [4.5 kg] or less), low bulk, easy to carry. Available in pressure-demand and continuous-flow modes.	Cannot be used for entry.	Provides only 5 to 15 minutes of respiratory protection, depending on the model and wearer's breathing rate.

confined spaces. Generally, only workers handling hazardous materials or operating in contaminated zones are equipped with SCBAs. By mandate, SCBAs may be approved (1) for escape only or (2) for both entry into and escape from a hazardous atmosphere. The types of SCBAs and their relative advantages and disadvantages are described in Table 10.3.

Escape-only SCBAs are frequently continuous-flow devices with hoods that can be placed directly over other respiratory face pieces to provide immediate emergency protection. Employers shall provide and ensure that employees carry an escape respirator where exposure to extremely toxic substances may occur. (An extremely toxic substance is defined as a gas or vapor having a Lethal Concentration of less than 10 ppm.)

Entry-and-escape SCBA respirators give workers untethered access to nearly all portions of the work site but decrease worker mobility, particularly in confined areas, due to both the bulk the and weight of the units. Their use is particularly advisable when dealing with unidentified and unquantified airborne contaminants. There are two types of entry-and-escape SCBAs: (1) open-circuit and (2) closed-circuit. In an open-circuit SCBA, air is exhaled directly into the ambient atmosphere. In a closed-circuit SCBA, exhaled air is recycled by removing the carbon dioxide with an alkaline scrubber and by replenishing the consumed oxygen with oxygen from a liquid or gaseous source or from an oxygen-generating chemical.

Any compressed-air cylinder used with a SCBA must meet U.S. Department of Transportation (DOT) "General Requirements for Shipment and Packaging" (49 CFR Part 173) and "Shipping Container Specifications" (49 CFR Part 178). Breathing-air quality must meet the requirements of Grade D breathing air as described by the Compressed Gas Association. These requirements include:

- Oxygen (O_2) content must be between 19.5 and 23.5 percent, with the remainder mainly nitrogen
- Hydrocarbon concentrations must not exceed 5 milligrams per cubic meter (mg/m^3)
- Carbon-monoxide (CO) concentrations must not exceed 20 parts per million (ppm)
- Carbon-dioxide (CO_2) concentrations must not exceed 1000 ppm
- There must not be any pronounced odor

Some of the key questions to ask when considering whether a SCBA is appropriate are:

- Is the atmosphere immediately dangerous to life or health? If so, an SCBA must be used.
- Is the duration of air supply sufficient for accomplishing the necessary tasks? If not, use a larger cylinder or modify the work plan.

- Will the bulk and weight of the SCBA interfere with task performance or cause unnecessary stress? If so, consider using an ALR if conditions permit.
- Will temperature effects compromise respirator effectiveness or pose added stress to the worker? If so, shorten the work period or postpone the mission until the temperature changes.

Respirator Fit Testing

The "fit" or integrity of the face-piece-to-face seal of a respirator affects its performance. A secure fit is important with positive-pressure equipment and is essential to the safe functioning of negative-pressure equipment, such as air-purifying respirators. Most face pieces fit only 60 percent of the population; thus, each piece must be tested on the potential wearer in order to ensure a tight seal.

To conduct qualitative fit testing, place the wearer in an enclosed space, such as a plastic bag, and expose him/her to either isoamyl acetate, a sweet saccarin/water mist, or an irritant smoke. The wearer should breathe normally, move the head from side to side and up and down, talk, and perform exercises in an exaggerated imitation of the task(s) to be performed and then breathe deeply, as during heavy exertion. If the wearer detects any of the test substance (banana-like smell; sweet taste; or irritation, coughing, or choking, respectively) the fit is inadequate. If the wearer does not detect any of the test substance, assign the exclusive use of that respirator to the worker or make the worker aware of the model and size respirator known to provide him/her with a proper fit. Conduct periodic checks to ensure that proper fit is maintained.

Fit tests obviously contain certain weaknesses. Isoamyl acetate is widely used in fit testing for organic-vapor air-purifying respirators, but its odor threshold varies

Figure 10.12 Here two workers are fit tested for respirator use.

among individuals. Also, isoamyl acetate can dull the sense of smell, thereby raising the detection threshold to very high levels. Irritant smoke is also used widely for fit testing. The irritant, commonly stannic chloride or titanium tetrachloride, comes in sealed glass tubes, which are broken open at test time Perform this test with caution, since these aerosols are highly irritating to the eyes, skin, and mucous membranes. The other qualitative fit tests are subjective and rely on the reaction and the honesty of the wearer.

Quantitative fit testing requires expensive testing equipment and is generally performed by manufacturers and testing organizations to determine protection factors. Portable testing devices are available, however. Leakage is expressed as a percentage of the test atmosphere outside the respirator and is called percent of penetration or simply penetration. Each test respirator is equipped with a sampling port to allow continual removal of an air sample from the face piece. Once tested, the face piece cannot be worn in service, as the test orifice negates the approval of the respirator (remember-this is a test respirator only). Quantitative fit testing is highly recommended for work in highly toxic and/or IDLH atmospheres.

Each time a negative-pressure respirator is donned for use, perform negative- and positive-pressure tests. To conduct a negative pressure test, close the inlet valve with the palm of the hand or squeeze the breathing tube so that it does not pass air and gently inhale for about 10 seconds. Any inward rushing of air indicates a poor fit. This is only a gross determination of fit: for example, a leaking face piece may be drawn tightly to the face to form a good seal, giving a false indication of adequate fit. To conduct a positive-pressure test, gently exhale (while covering the exhalation valve, if possible) to ensure that a positive pressure can be built up. Conduct both tests carefully in order to prevent disrupting a good fit or damaging the valve.

IN-USE MONITORING

During equipment use, supervisors and safety officers should encourage workers to report any perceived problems or difficulties to their supervisor as soon as possible. These malfunctions include but are not limited to:

- Discomfort
- Resistance to breathing
- Fatigue due to respirator use
- Interference with vision or communication
- Restriction of movement

If an air-line respirator is being used, remove all hazards that might endanger the integrity of the air line prior to use. During use, keep air lines as short as possible and keep other workers and vehicles away from the area to prevent any serious safety issues from occurring.

STORAGE

Respirators must be stored properly to prevent damage or malfunction due to exposure to dust, moisture, sunlight, damaging chemicals, extreme temperatures, and impact. Procedures must be specified for both preissuance warehousing and more importantly, postissuance (in-use) storage. Many equipment failures can be directly attributed to improper storage.

These are some tips for storage of respiratory equipment:

- Dismantle, wash, and disinfect SCBA air-line respirators and air-purifying respirators after each use.
- Store SCBAs in storage chests supplied by the manufacturer. Store air-purifying respirators individually in their original carton or carrying case or in heat-sealed or resealable plastic bags.

INSPECTION

All respirators must be inspected for wear and deterioration of components before and after each use. Special attention should be given to the rubber or plastic parts, which can deteriorate on all respirators. The face piece, especially the face-seal surface, headband, valves and connecting tube, fittings, and canister, must be in good condition. Respirator inspection must include a check of tightness of connections. SCBAs must be inspected at least monthly. Air and oxygen cylinders must be fully charged according to manufacturer instructions. Regulators and warning devices must be checked to see if they function properly.

If respirators are not in use, they must be inspected at least monthly. Your company policy may include more frequent inspections. Records must be kept of inspection dates and findings.

The following should be included on inspection checklists:

- Check condition of face piece for rotting and cracking
- Check headband for cracking and verify that it can be tightened without breaking
- Check the hose for cracking and the attachment points to the face piece and tank for o-rings and tightness of fittings
- Check the tank harness and straps of SCBA for cracks, tears, or other problems
- Check the regulator according to the manufacturer instructions
- Check the tank for cylinder damage
- Routinely practice donning the respirator if used infrequently or for emergency response

CLEANING OF RESPIRATORS

Respirators are washed in a detergent solution and rinsed and sanitized by immersion in a solution recommended by the manufacturer. All detachable parts, such as straps, valves, and gaskets, are removed, washed, rinsed, disinfected, rinsed again, and left to air-dry. When dry, the respirators are then reassembled, put in a clean storage bag, and stored for further use. Some steps should include:

- Remove the face piece from the air line or hoses
- Disassemble the respirator
- Inspect each component for wear
- Wash, rinse, disinfect, and rerinse each part
- Allow to completely air-dry
- Reassemble and reinspect the unit

SUMMARY

Respiratory protection is designed to protect the respiratory system of workers. It is one part of the body that doesn't heal itself. Workers tend not to wear respirators on occasion, as they cannot visually see the damage to their lungs and respiratory tract. Remember, from the toxicology section, that everyone's body reacts a bit differently to exposures. Therefore, we need to be careful in the selection and use of proper respiratory protection.

Training, proper selection of the respirator, fit testing, medical surveillance, record keeping and proper cleaning are critical to an effective respiratory-protection program. These items require input not only from management but from each and every worker involved in wearing respiratory protection. These pieces of equipment are issued for worker health and safety. They only serve that purpose if the wearer uses them properly!

11

ENGINEERING CONTROLS

Site-specific factors will determine administrative standard operating procedures at a hazardous- waste site. The chemical, physical, and toxicological properties of the waste are of primary importance, as is the amount present, the nature of work, and the potential for exposure during those activities. The decontamination process itself may affect the health and safety of workers.

Among engineering controls the most important principle, in my opinion, is the proper training of all workers in the operation and use of the equipment and tools. Improved (paved) roads, warning signs, adequate lighting, and installation of safety devices, including equipment guards, all add to increased worker safety. A daily inspection program of equipment, focusing on areas such as brakes, hydraulic lines, steering, light signals, and fire extinguishers, is essential in any organization. It is essential that any worker report problems immediately; leaks, strange odors, and failing equipment are significant problems that require attention. A maintenance program to inspect, check, test, repair, and replace equipment, accompanied by careful logging, is an integral part of site safety programs.

Excavations and trenches may be present at hazardous-waste sites and pose a hazard to workers. They need to be safely shored up or sloped to protect workers, and there should be a safe and convenient access path. Barricades may be necessary to prevent workers from falling into trenches or excavations.

BUDDY SYSTEM

The use of the buddy system is a requirement of the Hazwoper (Hazardous Waste and Emergency Response) regulation. Although it just makes good common sense to

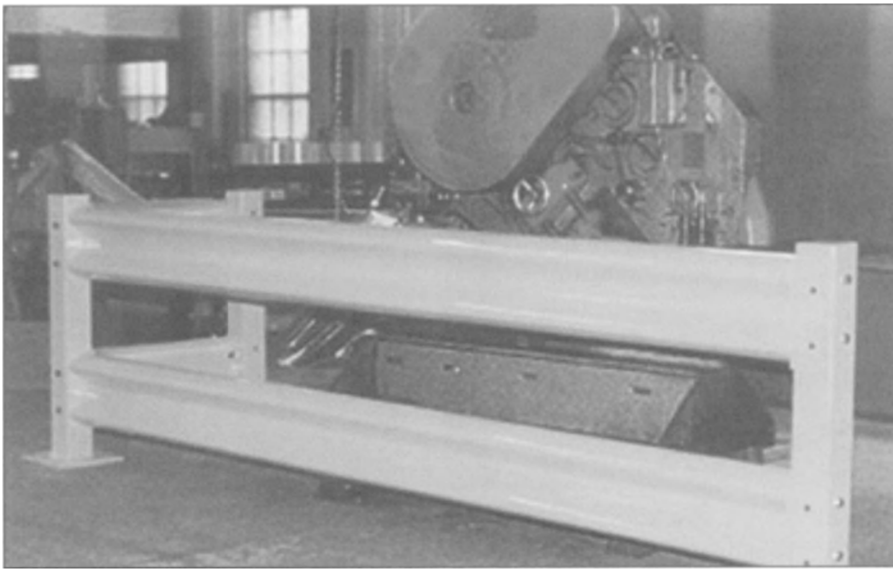


Figure 11.1 This equipment guard prevents injury to workers.

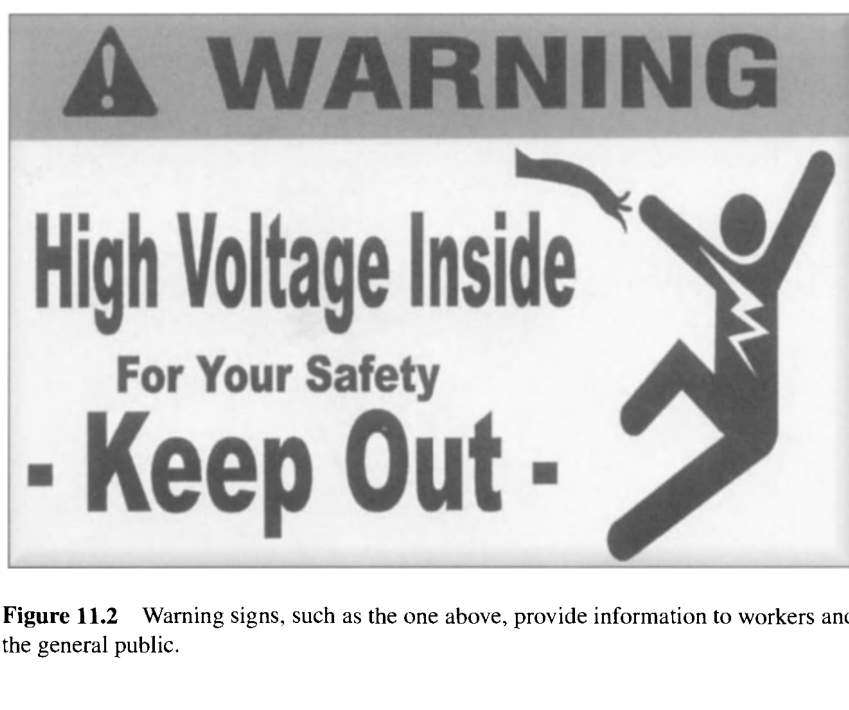


Figure 11.2 Warning signs, such as the one above, provide information to workers and the general public.

Fgure 11.3 Lighting is necessary when performing work after sundown or before sunrise.

work in pairs, the buddy system offers workers a number of advantages on the work site. This doesn't mean that partners have to hold hands when entering the work zones! But, it does mean that they should be nearby and available to each other for any help that might be needed. The buddy system is an effective way to observe each worker for signs of exposure and to keep an eye on the integrity of his or her protective equipment and clothing. Even with an assigned buddy, each worker should remain in line of sight of the command post if possible. A buddy system is in place for the following reasons:

- Provide partner with assistance (dressing in Personal Protective Equipment (PPE), removing PPE, assistance with various tasks assigned, etc.)
- Observe partner for signs of chemical or heat exposure (once in PPE workers may become hot or the suit may have a leak or hole and could cause the contaminant to affect the worker)
- Periodically check the integrity of partner's protective clothing
- Notify the command post in the event of an emergency

When at all possible, workers in the exclusion (hot) zone should be in line-of-sight or communications contact with the command post supervisor or a backup person in the support zone.

SITE SECURITY

As the name implies, site security involves keeping the work area secure. This means not only during working hours but also during off hours. Security may be necessary

Figure 11.4 The buddy system is a requirement of the Hazwoper standard. Here, two workers prepare to enter the hot zone.

onsite to exclude persons and thereby protect from unauthorized access and to prevent damage to equipment and tools. As most of us realize, the equipment and tools involved in hazardous-waste operations are extremely expensive and need to be secured at all times when not in use. From heavy equipment to small instruments used for analysis, thousands of dollars are at stake on many sites. There are several options available for security to maintain access control and safeguard equipment. These include:

- Police officers
- Private security guards
- Locks
- Card key access readers

Some of the reasons for security at hazardous-waste sites include the following:

- Prevent the exposure of unauthorized, unprotected people
- Avoid increased hazards from vandals
- Prevent theft
- Avoid interference

Figure 11.5 Security officer s help to keep unauthorized personnel from the site, as well as to keep traffic flowing smoothly during daily operations.

Figure 11.6 Locked and posted gates are important to the security at hazardous waste sites.

During working hours, site management can strengthen the company's security efforts by implementing some or all of the following:

- Maintain security in the support zone and at access control points
- Establish an identification system
- Assign responsibility for entry and exit
- Erect a fence around site
- Post signs or use guards to patrol the perimeter
- Approve all visitors to the site

Figure 11.7 This is the type of sign that many sites use to direct visitors to the proper location

During off duty hours, managers should consider the following suggestions for security:

- Assign trained, in-house technicians for site surveillance
- Use security guards to patrol the site boundary
- Enlist the local police department to increase patrols in the area
- Secure all equipment

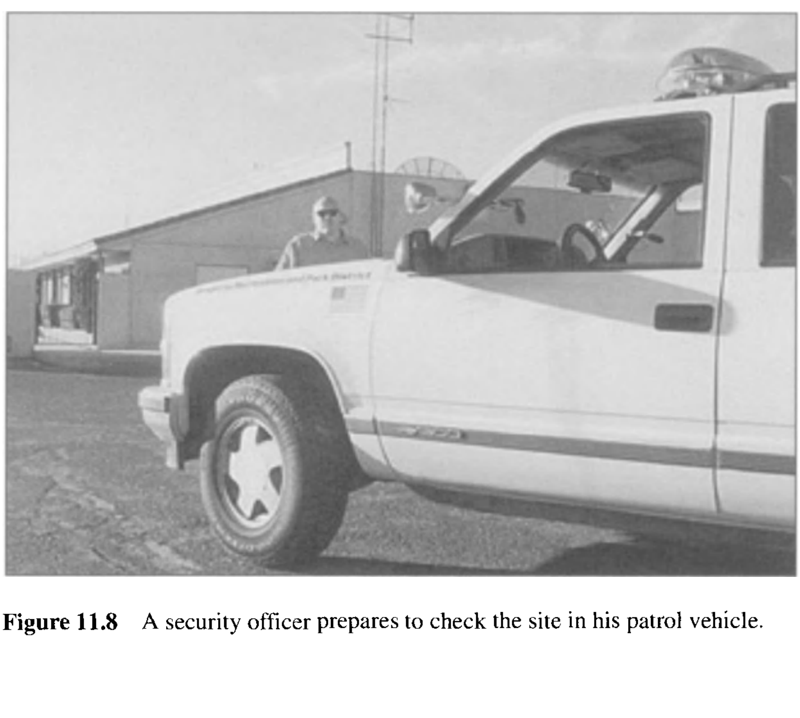


Figure 11.8 A security officer prepares to check the site in his patrol vehicle.

COMMUNICATIONS SYSTEMS

An effective communication system will keep workers and supervisors informed of internal vocal commands, sounds, and visual cues that signal work instructions or warnings. It should be easy to identify each worker from a distance by name, number, or color of protective clothing. External communication by telephone or radio is also necessary for emergency response as well as work instructions.

Two sets of communication systems should be established: internal communication among personnel onsite and external communication between on- and offsite personnel.

Figure 11.9 These workers are verifying drawings and checking with field crews by using two way radios and cellular phones.

Internal communication is used to:

- Alert team members to emergencies
- Pass along safety information
- Communicate changes in work assignments
- Maintain site control

For effective communication, commands must be arranged in advance and understood by all involved. In addition, audio or visual cues can help convey the message.

Internal communication devices include:

- Radio and cellular telephone
- Noisemakers— bell, compressed air horn, megaphone, siren, whistle
- Visual signals—flags, flashing lights, strobes, hand signals, colored lights, signal or arrow board

The worker's name could be marked on the suit and, for long-distance identification, color coding, numbers, or symbols may be added. All communication devices used in a potentially explosive atmosphere must be intrinsically safe and not capable of sparking. Communication devices should be checked daily to ensure that they are operating properly.

Figure 11.10 Note that this crew is dressed in blue chemical protective suits. Many firms use different colored garments to differentiate the duties that workers are performing. This group is preparing for decontamination.

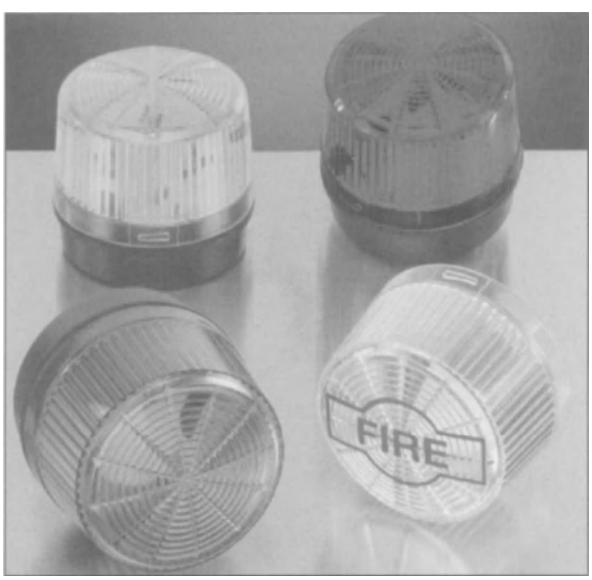


Figure 11.11 Strobe lights or flashing lights are a good way of providing warning or emergency information to workers. Many times these are used in areas where noise is a problem. Each color has a different indication or warning.

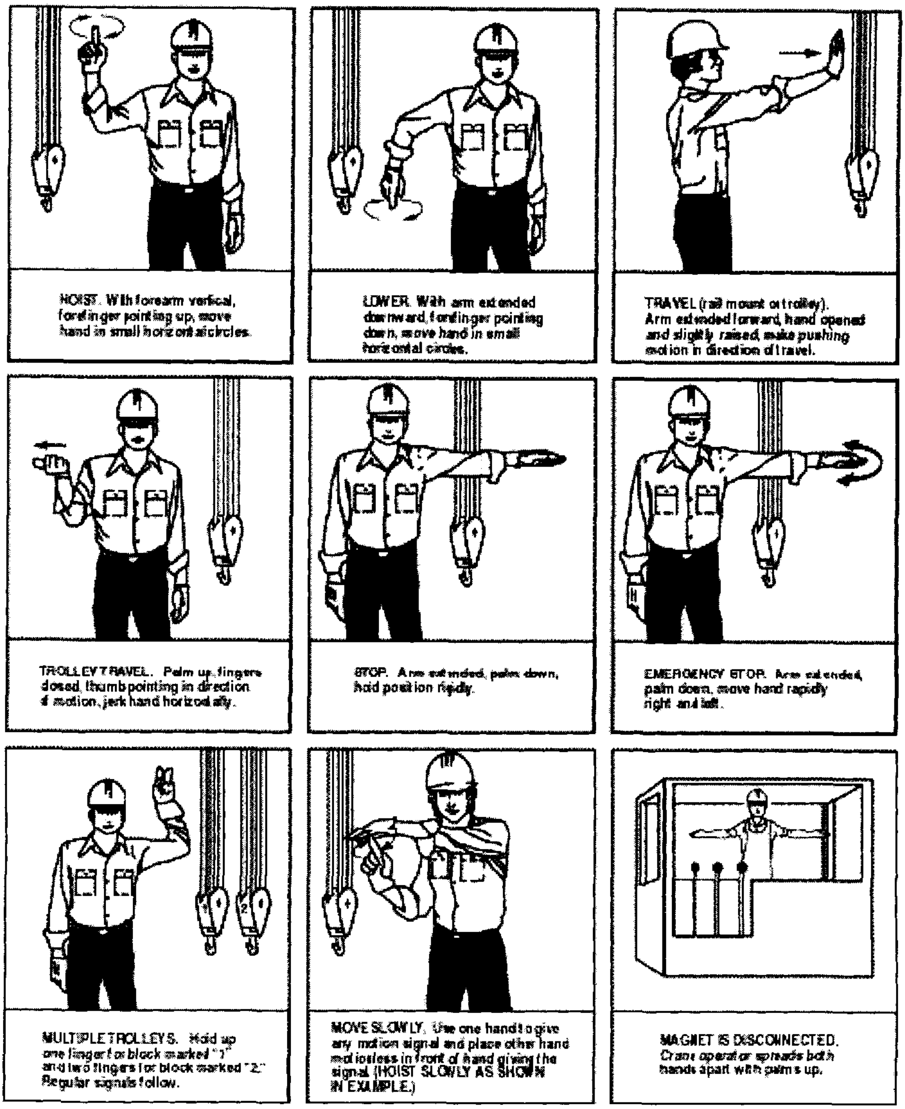


Figure 11.12 Hand signals such as those shown on this chart are used frequently on waste sites. This is used for crane operations.

An external communication system between on- and offsite personnel is necessary to:

- Coordinate emergency response activities
- Report to management or clients on significant issues
- Maintain contact with essential offsite personnel

Figure 11.13 This photo shows the daily planning meeting before daily activities starts. Photo taken by Alaska Department of Environmental Conservation.

Generally, the primary means of external communication is telephone (hardwired or cellular) or radio.

HANDLING HAZARDOUS-WASTE CONTAINERS

Practices and procedures for safe handling of drums and other hazardous-waste containers must be established and communicated to workers involved in this type of activity. The basic stages of handling will include:

- Inspection of the drum
- Planning its proper handling
- Handling the drum so it can be safely opened
- Opening
- Sampling
- The practices and procedures will proceed with the characterization of wastes
- Bulking or transferring of drum contents into bulk-type containers
- Shipment of bulked wastes to treatment, storage, or disposal facilities (TSDF)

Procedures for handling drums will depend on the contents of the drum. The individuals performing the inspection should be on the lookout for the following:

- Symbols, words, or other marks on the drum indicating that its contents are radioactive, explosive, corrosive, toxic, or flammable or that it contains discarded laboratory chemicals, reagents, or other potentially dangerous materials
- Signs of deterioration, corrosion, rust, leaks
- Signs that the drum is under pressure such as swelling or bulging.
- Drum type
- Configuration of the drumhead

Figure 11.14 This label on the drum indicates a corrosive material is (or may have been) in the container.

Monitoring should be conducted around the drums using instruments such as a radiation survey instrument, organic vapor monitor, or combustible gas indicator, as appropriate to the situation.

Personnel should assume that unlabeled drums contain hazardous materials until their contents are characterized or otherwise proven safe. Also, they should bear in mind that drums are frequently mislabeled. If buried drums are suspected, ground-penetrating systems can be used to estimate their location and depth.

Planning

Every step of the operation should be carefully planned. The results of the preliminary inspection can be used to determine:

- If any hazards are present
- The appropriate response
- Which drums need to be moved in order to be opened and sampled

A preliminary plan should be developed to specify the extent of handling, personnel roles, and procedures for the above items.

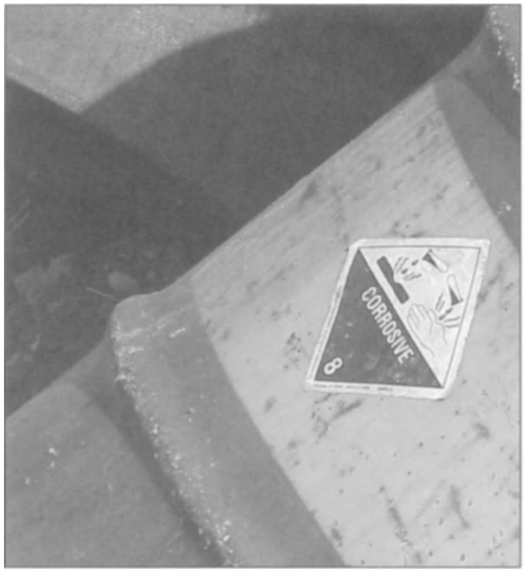


Figure 11.15 A rusty container without readable labels is found at a site. This type of container poses all sorts of potential problems to workers. What are some of them?

Figure 11.16 A bulging drum is found at a waste site. Opening the drum was done very carefully, so as not to spill contents or expose the entry team.

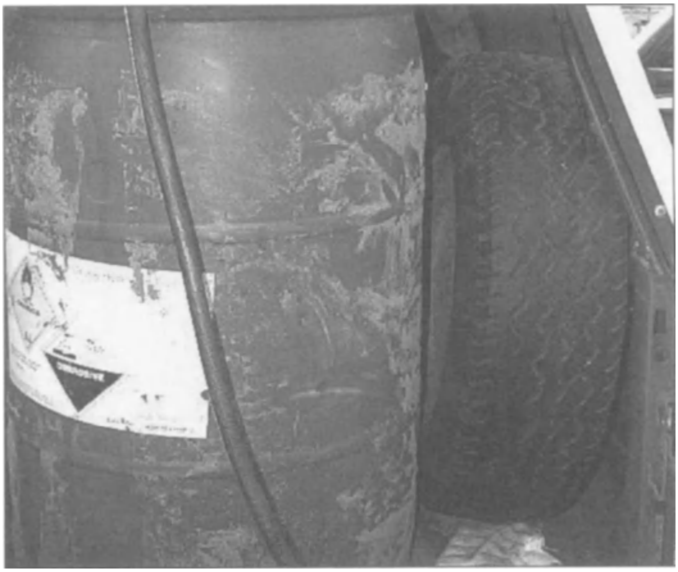


Figure 11.17 A plastic drum with labels affixed is found on a site on the West Coast.

Figure 11.18 A drum grappler moves two drums safely.

The purpose of handling is to:

- Respond to any obvious problems that might impair worker safety
- Stack and orient drums for sampling and eventual marking
- Facilitate characterization and remedial action(s)

Prior to handling drums, all personnel involved should be cautioned regarding the hazards of handling and instructed to keep it to a minimum. (The more times the drum is handled, the greater the chance of a mishap and/or injury.) Several types of equipment can be used to move drums, including:

- Drum grappler attached to a hydraulic excavator
- Small front end loader
- Forklift
- A roller conveyor
- Drum carts
- Drums are also sometimes moved manually.

In order to maximize worker safety, the following items should be considered by supervisors:

- Proper lifting and moving techniques to prevent back injuries (personnel should be trained in proper techniques of lifting safely)

Figure 11.19 A forklift moves several drums on a pallet. This saves the back and moves several drums at one time.

- Vehicle with sufficient rated loading capacity to operate smoothly on the road surface
- Air-conditioned vehicle cabs with heavy splash shields
- Appropriate respiratory protective equipment when needed
- Over packs ready before any attempt is made to move drums
- Appropriate sequence in which the various drums and other containers should be moved chosen
- Extreme caution taken in handling drums that are not tightly sealed
- Operators have a clear view of the roadway when moving drums.

Figure 11.20 The drum dolly or cart is another useful tool to move drums safely.

Packaged Laboratory Wastes

Laboratory packs (lab packs) can be an ignition source. Such containers should be considered to hold explosives or shock-sensitive wastes until otherwise characterized. If handling is required:

- Make sure all nonessential personnel are moved a safe distance away.
- Use a grappler unit constructed for explosive containment for initial handling of such drums.
- Maintain continuous communication with the site safety officer or a supervisor in the command post.
- Once lab packs have been opened, have a chemist inspect, classify, and segregate the bottles inside, without opening them, according to the hazards of the wastes. Pack these bottles with cushioning and absorption materials to prevent movement and to absorb free liquids. Vermiculite or wood shavings are typically used for this task; however, it is important to determine if the cushioning materials are compatible with the contents before using them. Lab packs are then shipped to an approved disposal facility.
- If crystalline material is noted at the neck of any bottle or cylinder, handle it as a shock-sensitive waste. Expert advice should be sought before making any attempts to handle it. This can be a very dangerous situation.

Bulging, Leaking, Open, Deteriorated, or Buried Drums

Whenever possible, workers should not move drums that may be under internal pressure. If a drum has to be moved, use a grappler unit constructed for explosive

Figure 11.21 The over pack drum actually will hold a fifty five gallon drum and its contents inside.

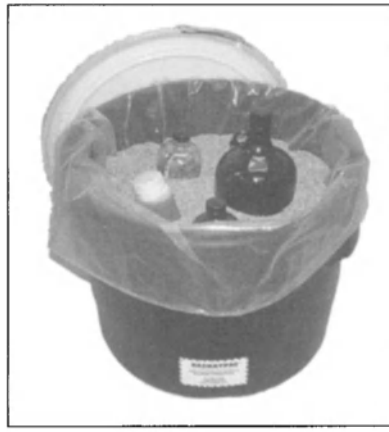


Figure 11.22 This is what is known as a lab pack. Note that the materials are placed into the drum and packed with a material such as vermiculite. The drum is lined with plastic first.

containment. Move the drum only as far as necessary to allow it to be set on firm ground or carefully place the drum in an overpack drum.

If a drum containing a liquid cannot be moved without rupture, transfer its contents to a reliable drum using a pump. The following drums should be placed immediately in overpack containers:

- Leaking
- Open
- Deteriorated

For buried drums or suspected buried drums, field workers should use ground-penetrating systems to estimate the location and depth of the drums and perform the following tasks:

- Remove soil with great caution to prevent rupture, leak, or explosion
- Have an appropriate type of fire extinguisher on hand to control small fires
- Ensure that there is a sufficient amount of containment or absorbent material handy in the even that a rupture occurs

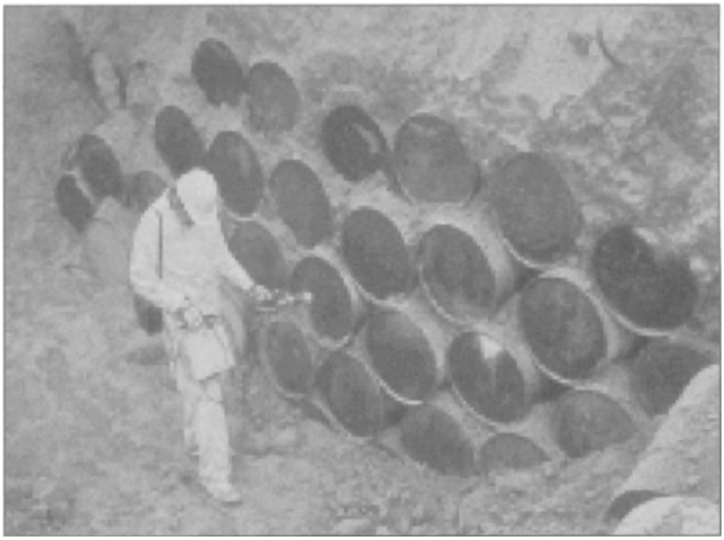


Figure 11.23 This worker is sampling around these buried drums

Drums are usually opened and sampled in place during site investigations. The following procedures should be instituted:

1. If a supplied-air respiratory protection system is used, place a bank of air cylinders outside the work area and supply air to the operators via air lines and escape self-contained breathing apparatus.
2. Keep personnel at a safe distance. If personnel must be located near the drums, place explosion-resistant plastic shields between them and the drums. Locate controls for opening equipment, monitoring equipment, and fire-suppression equipment behind the shield.
3. Monitor continuously during opening.
4. Use the following devices:
   - Pneumatically operated impact wrench to remove drum bungs
   - Hydraulically or pneumatically operated drum piercers
   - Backhoes equipped with bronze spikes
5. Do not use picks, chisels, firearms, or spark-producing tools to open drums.
6. If a drum shows signs of swelling or bulging, perform steps slowly. Relieve excess pressure prior to opening, if possible, from a remote location.
7. Open exotic metal drums and polyethylene or polyvinyl-chloride-lined (PVC) drums through the bung by removal or drilling.
8. Do not open or sample individual containers within laboratory packs.

9. Reseal open bungs and drill openings as soon as possible with new bungs or plugs. If an open drum cannot be resealed, place the drum into an overpack.
10. Decontaminate equipment after each use to avoid mixing incompatible wastes or contaminating subsequent samples.

Sampling

Prior to collecting any sample(s), a sampling plan must be developed and implemented. The following information is listed to assist the workers in developing a sampling plan:

- Research information about waste
- Determine drums to be sampled
- Select the appropriate sampling container
- Develop a sampling plan to include number, volume, and locations
- Develop standard operating procedures (SOPs) for opening drums, sampling and sample packaging, and eventual transportation
- Have a trained health and safety professional determine, based on available information about the wastes and site conditions, the appropriate level of personal protective equipment to be used during sampling, decontamination, and packaging of the sample

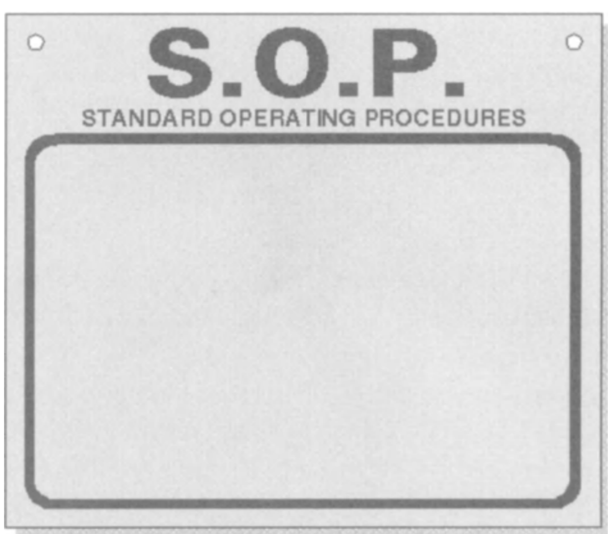


Figure 11.24 SOP Manuals should be available for use by field personnel.

Often it is necessary to manually sample the drums or containers onsite. When manually sampling from a drum the employee should follow these guidelines:

- Keep sampling and other nearby personnel at a safe distance while drums are being opened
- Do not lean over other drums to reach the drum being sampled
- Cover drum tops with plastic sheeting to avoid any contact
- Never stand on top of drums
- Obtain samples with either glass rods or vacuum pumps; glass rods should be removed prior to pumping to avoid any damage to pumps

Characterization

Characterization obtains the data necessary to determine how to safely and efficiently package and transport wastes for treatment and disposal. If wastes are bulked, they must be characterized to determine which can be safely combined. Standard tests should be used to classify the wastes into general categories, including autoreactive materials, water-reactive materials, inorganic acids, organic acids, heavy metals, pesticides, cyanide, inorganic oxidizers, and organic oxidizers.

Figure 11.25 These workers are sampling a drum using a glass rod.

Staging

Drums must sometimes be staged—moved in an organized manner to predesignated areas—to facilitate characterization and remedial action and to protect drums from potentially hazardous site conditions.

The number of staging areas necessary depends on the scope of the operation, accessibility of drums, and hazards. Remedial and emergency operations can involve extensive drum staging. Up to five separate areas have been used:

1. Initial staging area: drums (1) organized according to type, size, and suspected contents and (2) stored prior to sampling
2. Opening area: drums are opened, sampled, and resealed
3. Sampling area: remedial or emergency tasks set up some distance from the opening area
4. Second staging area: a holding area where drums are temporarily stored after sampling pending characterization of their contents
5. Final staging area: a bulking area where substances that have been characterized are bulked for transport to treatment or disposal facilities; locate the final staging area next to the site's exit, and:

- Grade the area and cover it with plastic sheeting
- Construct foot-high dikes around the entire area
- Segregate drums according to their basic chemical categories (acids, heavy metals, pesticides) as determined by characterization and construct separate areas for each type

Figure 11.26 Drums are stored on pallets with sufficient space between rows.

In all areas, stage the drums two across in two rows per area and space these rows 7 to 8 feet apart.

Bulking

Wastes that have been characterized are often mixed together and placed in bulk containers such as tanks or vacuum trucks to increase the efficiency of transportation to treatment or disposal facilities. Workers should use the following procedures as guidelines when bulking:

- Inspect and remove any residual materials from the trailer
- To move hazardous liquids, use pumps that are properly rated and that have a safety relief valve with a splash shield
- Inspect hose lines to ensure that all lines, fittings, and valves are intact with no weak spots
- Protect personnel against accidental splashing and protect lines from vehicular and pedestrian traffic
- Store flammable liquids in approved containers

Shipment

Shipment of materials to offsite treatment, storage, or disposal facilities involves the entry of waste hauling vehicles into the site. The United States Department of Transportation (DOT) and Environmental Protection Agency (EPA) regulations for shipment of hazardous wastes must be observed. Guidelines for safety include but are not limited to the following:

- Minimize conflict between cleanup teams and waste haulers; install traffic signs, lights, and other control devices
- Provide adequate area for onsite and hauling vehicles to turn around
- Stage hauling vehicles in a safe area until ready for loading, with drivers remaining in cab
- Outfit the driver with appropriate protective equipment
- If drums are shipped, tightly seal the drums prior to loading and do not double-stack; overpack leaking or deteriorated drums prior to shipment (Under most circumstances, overpack drums used for hazardous wastes may not be reused.)
- Make sure that truck beds and walks are clean and smooth to prevent damage to drums
- Drums should be secured to prevent shifting during the transportation process
- Keep bulk solids several inches below the top of the truck container to avoid splashing or losing the contents; cover all loose loads with a layer of clean soil, foam, and/or tarp

- Weigh vehicles periodically to ensure that vehicles are not releasing dust or vapor emissions offsite
- Decontaminate vehicle tires (and any other portion of the vehicle requiring decontamination) prior to leaving the site to ensure that contamination is not carried onto public roads
- Check every so often to ensure that vehicles are not releasing dust or vapor emissions off-site.
- Develop procedures for responding quickly to offsite vehicle breakdown and accidents to ensure minimal public impact

Vacuum Trucks

The following are helpful hints to use when operating on or near vacuum trucks and equipment. Site personnel should always wear and use the appropriate level of personal protective clothing and equipment when opening the hatch and follow these procedures:

- Use mobile steps or suitable scaffolding; avoid climbing up the ladder or walking across the tank catwalk
- If truck must be climbed, raise and lower equipment and samples in carriers; workers should try to use both hands while climbing
- Sample from the top of the vehicle; if it is necessary to sample from the drain spigot, take steps to prevent any leaks or spraying of excessive substances

Figure 11.27 Mobile steps are used to get to the tops of vehicles such as vacuum trucks.

Figure 11.28 A vacuum truck empties its load into the designated area at a disposal facility.

Elevated Tanks

Elevated tanks are just one more hazard that site personnel may have to encounter. All site personnel must observe the safety precautions described for vacuum trucks as well as the following:

- Use a safety line and harness arrangement
- Maintain all ladders and railings in accordance with OSHA requirements
- Follow any other company policy, procedure, or guideline related to this operation
- Follow all related federal, state, and local guidance with respect to elevated tanks

Compressed Gas Cylinders

Supervisors and all other site employees are asked to obtain expert assistance whenever they encounter compressed gas cylinders on site. These cylinders can be lethal if handled improperly. If you are not sure, I would suggest that you ask your supervisor or foreman for specific guidance or directions. In the event that management personnel do not have adequate answers for your questions, they should be able to direct you to expert assistance. The following are guidelines for handling compressed gas cylinders:

Figure 11.29 This elevated tank has steps that allow workers easy access to it.

- Handle compressed gas cylinders with extreme caution
- Use protective equipment if necessary, but in all case, wear the appropriate hand protection (gloves)
- Never lift the cylinder by the cylinder cap (it may be loose and come off)
- Record identification numbers on cylinders to aid in the characterization of cylinder contents

Figure 11.30 These compressed gas cylinders are properly stored and secured in a cage with labels identify full and empty.

Ponds and Lagoons

Many hazardous-waste sites are located in areas that have a pond, lagoon, or other body of water. Because drowning is a very real danger for personnel suited in protective equipment due to its weight, the following suggestions are offered:

- Provide lifeboats, life rings, tag lines, railings, nets, safety harnesses, and flotation gear

Figure 11.31 Life rings should always be at the ready in areas where ponds, lakes and steams exist.

Figure 11.32 Life jackets must be worn by personnel working within 10 feet of the water's edge or performing on water operations.

- Provide life vests/jackets as needed
- Check to ensure that workers in these areas can swim
- Avoid going out over the water, if possible
- Be aware solid wastes may float, giving the appearance of solid cracked mud

Tanks and Vaults

Hazardous-waste site work frequently involves working in and around tanks and vaults. Again, safety is the number one rule. The following guidelines are offered for tanks and vaults:

- Follow the same procedures as for a sealed drum vent excess pressure if volatile substances are stored; place deflecting shields between workers and the opening
- Guard manholes or access portals and allow only authorized personnel into these areas
- If characterization indicates that the contents can be safely moved, vacuum them into a trailer for transportation and proper disposal
- Decontaminate tank or vault before disposal
- Follow confined space entry regulations if the space meets these requirements

Confined Spaces

If it is necessary to enter a tank, vault, or other confined space for any reason (to clean off solid materials or sludge on the bottom or sides of the tank or vault or for repair, maintenance, or surveillance), the following precautions should be taken by all personnel:

- Determine if the space meets the definition of a confined space (limited access/egress; large enough opening to perform work; not designed for human occupancy)
- Perform stratification air monitoring of the entire space (top, middle and bottom)
- Ventilate the space thoroughly prior to personnel entry
- Continue monitoring if necessary
- Disconnect connecting pipelines
- Prior to entry take air samples to prove the absence of flammable or other hazardous vapors and to demonstrate that adequate levels of oxygen exist

Examples of Confined Spaces

In addition to tanks and vaults, common examples of confined spaces include boilers, tunnels, wells, bins, sewers, manholes, and other underground locations. Whether below or aboveground, any work area with poor ventilation must be considered to be a confined space.

The danger of confined spaces increases greatly when hazardous wastes have been used or are being stored in them. Although the area may have been cleaned, residues of hazardous substances still may pose a danger.

Three Primary Dangers

The number of accidents and fatalities in confined spaces is staggering. Hundreds of people are killed and injured annually, primarily due to oxygen deficiency, combustion, or toxicity. Oxygen-deficient atmospheres are the number one cause of death in confined space situations.

Because lack of oxygen is the leading killer of workers in confined space accidents, it is essential that oxygen levels be tested with proper equipment prior to all entries into a confined space. Air normally consists of about 21percent oxygen. Symptoms such as rapid breathing, speedy heartbeat, drowsiness, and nausea develop when the oxygen level drops to about 16percent. Unconscious-

Figure 11.33 Signs like this one are to be posted outside all confined spaces requiring a permit to enter.

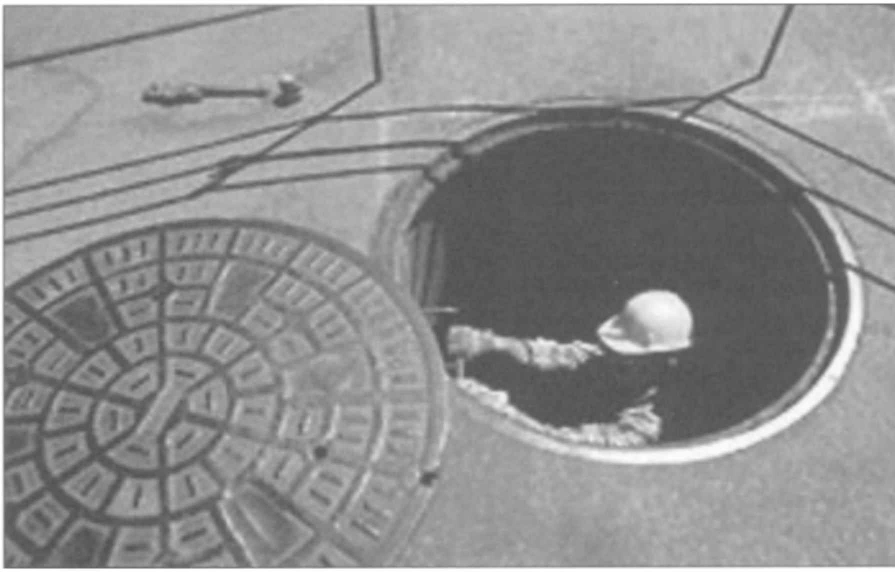


Figure 11.34 A worker is shown inside a manhole (confined space).

ness will generally occur by the time the oxygen level lowers to 12 percent, and death will occur at a level of 6 percent oxygen. Wearing the necessary respiratory equipment is an absolute lifesaver. Oxygen deficiency may result from fire, explosion, corrosion, or displacement by other gases (maybe from the work being performed in the space).

Combustion is a greater danger in confined spaces than in open spaces because ignition can occur more easily in trapped air. Natural substances pose an explosion risk, as do solvents, petroleum products, chemicals, and paint-related products. Sparks, metal friction, static electricity, and dangerous lighting fixtures all can ignite gases or vapors that have built up in the confined space. Cigarette, cigar, or pipe smoking is prohibited in all confined spaces—or anywhere else at a hazardous-waste site, for that matter.

Toxins will irritate the respiratory and nervous systems. Large amounts of these toxins can be fatal in a confined space. Chemical asphyxiation is a real danger. Symptoms of asphyxiation include:

- Nausea
- Headache
- Dizziness
- Drowsiness

These symptoms may be disabling, thereby preventing escape from the confined space by the entrants. Four of the common toxins are:

- Carbon monoxide
- Carbon dioxide
- Sulfur dioxide
- Hydrogen sulfide

Carbon dioxide results from internal combustion using gasoline, propane, wood, coal, or oil as fuel.

Carbon monoxide is a gas used in firefighting and refrigeration. Sulfur dioxide, produced in plastic and paper manufacturing, is a toxic danger when present even in small amounts. Hydrogen sulfide, produced in industrial processes, including sewage and petroleum treatment, is immediately life-threatening if inhaled.

Other added hazards in confined spaces include but are definitely not limited to:

- Noise
- Heat stress
- Exhaustion
- Falls

Safety Procedures

Personnel must always be aware of their surroundings, especially in confined space situations. Companies should consider the development of safety policies and procedures. A written program is required by the Occupational Safety and Health Administration. Basic safety procedures when working in confined spaces include:

- Testing for oxygen deficiency, combustibility, and toxic substances both prior to entering and when inside the space
- Maintaining adequate ventilation at all times
- Wearing appropriate respiratory equipment and personal protective clothing appropriate to the potential hazards present in the space
- Eliminating all ignition sources and potential fuels that create fire or explosion hazards
- Having a rescue plan and rescue workers available within a reasonable amount of response time to the confined space

Confined spaces are regulated under the Occupational Safety and Health Administration. Personnel should consult the current regulation for assistance. The scope of the regulation includes confined spaces as described above and also silos, vessels, compartments, ducts, pipelines, tubs, and pits. The confined space is defined as one in which insufficient ventilation may lead to oxygen deficiency or dangerous air con-

Figure 11.35 A safety officer performs air monitoring of this space prior to entering.

tamination. It is further defined as having difficult access for removal of a disabled worker. A more formal type of definition of a confined space is any space lacking natural ventilation; a space large enough for human occupancy but not designed for humans to occupy for any length of time; and a space that has limited access for entry and egress not necessarily at the top.

Operating and rescue procedures must be in writing and provided to employees, who need to be trained in the procedures and instructed as to the possible hazards. Preentry rules call for disconnection of lines conveying hazardous substances to the space and emptying of those substances from the space. The air must be tested to determine the extent of dangerous air contamination or oxygen deficiency, a record kept, and workers given a chance to see the record.

If these hazardous air conditions do exist, then additional ventilation must be provided to correct the situation and the air retested. Flammable or explosive substances must be eliminated before ignition sources can be brought into the space, and oxygen-consuming equipment such as torches and furnaces are prohibited until measures are taken to guarantee adequate combustion air and exhaust gas venting.

Entry into confined spaces and work operations within those spaces are also regulated. When a tank, vessel, or other space has side and top openings, entry from the side openings is required whenever possible. Approved respiratory equipment must be provided and worn. Approved safety harnesses with attached lines that are secured outside the entry must be used. There must be two or more rescue workers available to respond within a reasonable amount of time (generally this is considered to be 4 to 6 minutes). Rescue personnel must be trained in first aid and cardiopulmonary resuscitation. It is ideal if the rescue team is stationed immediately outside the space or otherwise readily available by call or preferably within line of sight. After alerting another employee and being properly relieved by another authorized attendant, the standby rescuer, wearing the appropriate respiratory equipment (if required) with an independent air source, may enter the space in an emergency situation.

Entry from the top opening into a confined space requires use of a harness safety belt, one that can suspend the worker in an upright position. Workers should be lifted out of the space with a hoisting device, such as a tripod and winch arrangement.

Ignition sources are prohibited when dangerous air contamination is present or may develop, creating a potentially flammable or explosive condition. Approved lighting and electrical equipment may be used if it has been determined that it is safe to do so. Appropriate personal protective clothing or devices shall be provided, worn, and used by workers entering confined spaces that have contained corrosive substances.

Figure 11.36 This picture depicts a trench being dug to remove chemical contamination.

Trenching and Excavation Safety

Figure 11.37 This is the Dig Safe sticker that is prominent in the Northeast part of the United States. Check with the local authorities in you area to find out who to call prior to digging.

Each year workers are killed and disabled in excavation and trench cave-ins. Almost all these accidents result from failure to shore or slope the trench or from inadequate shoring or sloping. These guidelines are based on OSHA standards for shoring, sloping, and benching. Again, this is not a legal interpretation or a restatement of current OSHA regulations. Refer to the OSHA regulations on trenching and excavations for current rules.

Prior to Digging

Obtain the required permit (if your jurisdiction requires this) from the appropriate state or local agency before constructing trenches or excavations 5 feet deep or more in which a person may be required to work. This may mean that you will have to contact a District or Field office for information regarding the permit application procedure or process. Supervisors should determine whether any underground installation such as sewer, water, or fuel lines are likely to be encountered at the site. All work in an excavation must be supervised by a competent person, per the Occupational Safety and Health Administration.

Hazards near Excavations

Remove trees, poles, boulders, and similar objects that may be hazardous to workers prior to the commencement of work. Do not allow work in or near the excavation until a competent person has determined that no hazard to workers exists from possible moving ground. Excavations must be inspected after rainstorms, thaws, or other events that may affect the stability of the soil and/or increase the hazards to personnel before workers are allowed to enter the excavation.

Workers who enter excavations 5 feet deep or more must be protected with a system of shoring, sloping, benching, or equivalent alternative methods. When necessary, the company must provide similar protection for workers in excavations less than 5 feet deep (if the situation warrants this type of protection).

Key areas to focus on when dealing with excavation sites include:

- Dump excavated material (referred to as the spoils pile) far enough from the edge of the trench so that it does not fall back (approximately 2 to 3 feet). When trenches are 5 feet deep or more, locate the spoils pile a minimum of 2 feet from the edge. Do not obtain the spoils by any method that will disturb the soil already in place (such as driving stakes or rods).

- Provide a safe and convenient way for workers to enter and leave the excavation. In trenches 4 feet deep or more, provide a safe means of access within 25 feet of any worker in the excavation. Ramps or ladders are certainly options.
- Install crossings with standard guardrails and toeboards when the excavation is more than 7½feet deep.
- Do not excavate beneath the level of the base of an adjacent foundation, retaining wall, or other structure until a qualified person has determined that the earthwork will not create a hazard to workers. Support undermined sidewalks so they will bear anticipated loads.
- If the excavation endangers the stability of adjoining structures, shore, brace, or underpin those structures as soon as possible. The use of trench boxes will help.
- Do not use an existing wall or structure as a retaining wall until it has been determined that it will safely support expected loads.
- Provide barriers to prevent workers from falling into excavations. Barricade or securely cover all wells, pits, shafts, and caissons.
- Use diversion ditches, dikes, and other effective methods to prevent water from entering the excavation and to drain surrounding areas.
- Use additional bracing to strengthen shoring in excavations located near streets, railroads, or other sources of vibration and external loads. Take similar precautions when excavations are made in areas that have been previously filled.

Figure 11.38 This is a trench box. It allows workers to enter the space without fear of collapse of the soil.

Shoring, Sloping, and Benching Systems

Devices should be provided that allow the upper cross braces to be set in place from ground level. In deep trenches where additional braces are needed, workers should proceed downward, protected by cross braces already set in place. When removing shoring, use the reverse procedures. Install shoring in accordance with established guidelines, industry standards, or plans prepared by a registered civil engineer.

Shoring must be composed of:

- Solid wood sheeting or wood sheet-piling not less than 2 inches thick
- Plywood at least 1⅛ inches thick
- Wood uprights at least 2 inches by 8 inches
- Wood braces and diagonal shores at least 4 inches by 4 inches and not subjected to compressive stress in excess of values given by the following formula:
  S = 1300—(20/D)
  Maximum ratio (L/D) = 50
  L—length, unsupported (in inches)
  D—least side of the timber (in inches)
  S—allowable stress (in pounds per square inch of cross-section)

The tie rods must be securely anchored when they are used to restrain the top of sheeting of other restraining systems. Workers should always assume that there is full loading due to groundwater when using tight sheeting or sheet piling (unless full

Figure 11.39 This excavation is sloped to allow workers to enter safely.

loading is prevented by weep holes, drains, or other methods). Companies should provide additional stringers, ties, and bracings to allow temporary removal of individual supports.

For trench shoring systems, do not slope a in excess of 15 degrees from the vertical. Make uprights at least 2 inches in nominal thickness. Plywood panels at least _ inch thick may be installed behind the uprights to hold loose material not likely to impose heavy loads. Extend uprights to the top of the trench and to within at least 2 feet of the bottom. If running soil is encountered, extend uprights to the bottom of the trench.

For cross braces, always use at least two braces. Install one horizontal brace for each 4-foot zone or partial zone measuring 2 feet or more. Use metal-screw-type trench jacks with a base on each end or timbers placed horizontally against the uprights or stringers. Hydraulic braces may also be used.

For protective shields and welding huts, have plans prepared and approved by a registered civil engineer (registered in the state you are working in). Construct protective shields and welding huts out of steel or other material providing equivalent strength. They must provide protection equivalent to that afforded by adequate shoring.

For sloping or benching systems used as a substitute for shoring, the slope should be at a ratio at least three-quarters horizontal to one vertical unless the instability of the soil requires a flatter slope. For exceptions, see illustrations following the text.

Shafts

All wells or shafts over 5 feet deep in which workers are allowed to enter must be retained with lagging, spilling, or casing. Extend at least 1 foot above the ground, the full length of the shaft, and at least 5 feet into solid rock (if possible).

For small shafts in hard, compact soil, 2-inch cribbing can be used in square shafts not over 4 feet square. Cut halfway through the width of the member and dovetail into position so that each member will act as a shore as well as lagging. Nail strips need to be placed in the corner to prevent boards from dropping down.

For shafts in other than hard or compact soil, use a system of lagging supported by braces and corner posts for square or rectangular shafts. In shafts 4 feet square or smaller, use 4-inch-by-4-inch members at intervals of no more than 4 feet. Braces and corner posts in larger shafts should be correspondingly larger. The appropriate size should be determined by a registered civil engineer.

Completely lag around shafts with 2-inch material supported by adjustable rings of metal or timber at intervals of no more than 4 feet or case in a way that provides equivalent protection.

For bell excavations, include the following to protect workers engaged in belling or enlarging the bottoms of shafts:

- Physical protection from potential ground movement or collapse
- Mechanical ventilation
- A line for instant rescue fastened to a shoulder harness and worn by each worker entering the shaft

- A hoist and platform for lifting and lowering workers in shafts over 50 feet deep
- Barriers to prevent materials from falling into the shaft

Earthwork and Excavating

Install a bench or other method of working if the height and the condition of the face pose a hazard to workers. When a bench method of operation is needed, construct a setback of at least one-half the height of the single face or bank for each section of the face or bank.

The maximum slope of the face depends on:

- The nature of the materials being excavated
- The height of the face
- The compaction of the material
- The type and size of the equipment used at the face and the amount of protection this equipment affords the operator
- The safety of workers not protected by such equipment

Procedures to follow with excavations include:

- Do not make the slope steeper than a ratio of 3/4:1 when the height of the excavation is greater than the bucket of the excavator or loader can reach and when the face is composed of loose or raveling material (soil)
- Do not allow a slope steeper than 3/4:1 when the height of the excavation is greater than the bucket of the excavator or the loader can reach when the face is composed of material that will stand in place but that is not firmly cemented or consolidated
- Do not allow a person under a face or bank where stripping or any other similar operation constitutes a hazard
- Use barriers, baffle boards, screens, or other devices to protect workers from material rolling or sliding down the slopes

Face Inspection and Control

Supervisory personnel should make daily inspections of faces, banks, and tops where workers are exposed to falling or rolling material. All deficiencies and unsafe conditions must be corrected prior to the commencement of work or immediately upon discovering the problem. Do not allow anyone to work near an unsafe face under any circumstances.

Prohibit overhanging banks except as follows:

- When material is moved by mechanical equipment with controls at a safe distance
- When the bank is undercut by a stream and the monitor is located a safe distance from the bank

When necessary, a worker should be stationed at the face who is instructed to give a warning when loose rock or other materials begin to fall. This worker must be provided with the means of giving adequate warning to other workers. While the worker is assigned to this job, do not assign her/him to any other work. Some of the ways to warn others include:

- Air horns
- Whistles
- Bull horns with siren attachments

Workers must have enough illumination provided for safe night operations. Night work should not be allowed unless the working area is sufficiently illuminated so that movement of workers and equipment can be easily seen. Headlights from a vehicle or flashlights do not constitute sufficient illumination on a site. High-powered lights must be used so that workers can see what they are doing. Keep workers away from dangerous areas by posting "KEEP OUT" signs or erecting barricades where appropriate to do so.

All work above or below workers at the face should be prohibited if such work endangers their safety.

On top of the bank, this includes the following precautions:

- Use a fence with guardrails or ropes
- Use a railed platform
- Have workers use safety belts and lifelines

Some exceptions to these rules include the following:

- When the bank is less than 20 feet high
- When the slope is flatter than 3/4:1
- When no work is being done within 10 feet of the edge

On the face, the following should be considered:

- Remove loose rock from over the working place
- Have workers use safety belts and lifelines (Life lines used for scaling or inspection should be protected from excessive fraying or damage and made of a minimum of 7/8-inch wire-core manila rope)
- Use portable staging
- Use a boatswain chair or skips especially designed for faces (when using a boatswain chair, also use a safety belt and lifeline equipped with an effective descent control)

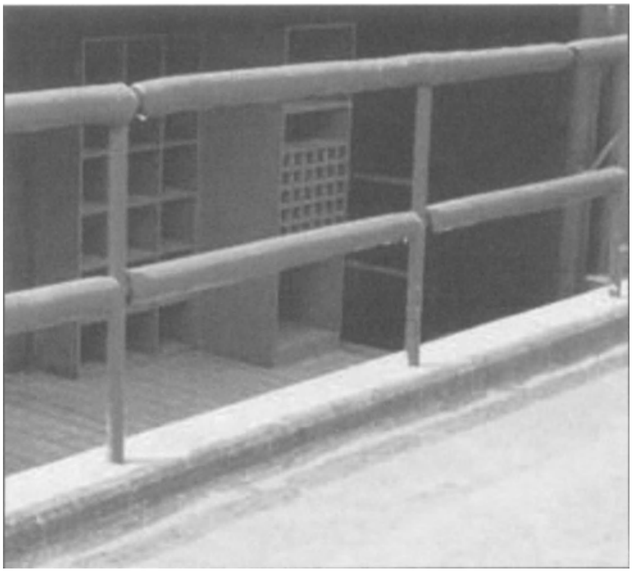


Figure 11.40 Guardrails like this one are often erected at sites for safety and security.

- Assign two or more workers to cooperate with each other on drilling, blasting, or removing loose rock

At the foot of the bank, these are some suggestions to use:

- Remove loose rock from above the working place
- Maintain a ready exit to a place of safety

SUMMARY

Engineering controls are an essential part of safety at hazardous-waste sites. Although not every site will require excavation and trenching operations, a large portion will. Many of the topics discussed in this chapter will make our jobs easier and safer to perform. Managers, supervisors, and workers should all use engineering controls as another tool in the "toolbox" that may be available for consideration during hazardous–waste-site operations.

Many sites have confined space issues associated with them. Others will require some sort of ventilation to reduce contaminants in the air. All sites will require engineering controls of some type. While many of us in this business are not degreed engineers, we will still have to use our skills to work out a safe and reliable solution to many of the problems we will encounter at the job site.

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE MANUAL
by Brian J. Gallant

12

SITE EMERGENCIES

The nature of work at a hazardous-waste site makes an emergency a frequent possibility, no matter how occasionally it may actually occur. Emergencies happen quickly and unexpectedly and often require immediate action by site workers or offsite responders. At a hazardous-waste site, an emergency may be as minor as a worker experiencing heat stress or as serious as an explosion that spreads a toxic cloud throughout the entire community. Any hazard onsite can precipitate an emergency: chemicals, biological agents, radiation, or physical hazards may act alone or in combination to create explosions, fires, spills, toxic atmospheres, and/or many other dangerous and harmful situations. Table 12.1 lists some of the more common causes of site emergencies.

Site emergencies are characterized by their potential for complexity: uncontrolled toxic chemicals may be numerous and unidentified; their effects may be synergistic. Hazards may compound one another—for example, a flammable spill may feed a fire. Rescue personnel attempting to remove injured workers may themselves become victims. This variability means that advanced planning, including anticipation of different scenarios and detailed preparation for contingencies, is essential to protect workers as well as community health and safety.

This chapter outlines important factors to be considered when planning for and responding to emergency situations. It defines the nature of site emergencies, lists the types of emergencies that may occur, and outlines the components of a contingency plan, which include personnel roles, lines of authority, training, communication systems, site mapping, site security and control, refuges, evacuation routes, decontamination, a medical program, step-by-step emergency-response procedures, documentation, and reporting to outside agencies.

Table 12.1 Common causes of site emergencies

Spills or leaks of chemicals or hazardous waste
Refueling equipment resulting in fire due to hot surface
Personnel not sufficiently hydrating in hot weather
Laceration due to improperly using cutting blade
Slip, trip or fall on uneven terrain resulting in broken bone or abrasion
Burn to extremity by touching hot exhaust of machinery
Poison ivy from performing site preparation
Bit by spider while sampling a drum
Electrocution from improperly grounded tool
Inhalation of benzene during remediation activities
Oxygen deficient atmosphere in a confined space resulting in death
Exposure to Carbon monoxide under a dock area performing chemical remediation
Worker struck by overhead crane
Worker contacted dirty needle while performing beach clean up at an oil spill

PLANNING

We've all heard the words, "It can't happen to me, "or "I know what I'm doing; I've been at this for fifteen years." Guess what? Tragedy can and often does happen to those very people! When an emergency occurs, decisive action is vital. Rapidly made choices may have far-reaching and long-term consequences. Delays of minutes can create life-threatening situations. Personnel must be ready to immediately rescue or respond; equipment must be on hand and in good working order. In order to handle emergencies effectively, planning is essential. For this purpose, a contingency plan should be developed.

A contingency plan is a written document that sets forth policies and procedures for responding to site emergencies. At a minimum, it should incorporate the following information:

- Personnel (roles, lines of authority, training, communication)
- Site (mapping, security and control, refuges, evacuation routes, decontamination stations)
- Medical /first-aid stations
- Equipment
- Emergency procedures
- Reporting Procedures (include agencies, contact information, etc.)

Figure 12.1 Several members from industry and Federal agencies involved in a drill scenario

Generally, a contingency plan should be designed as a distinct section in the Site safety plan, but it can also be a stand-alone document. If it's a stand-alone document, then you'll need to remember that it, plus the site safety plan, must be reviewed and modified, rather than having both in one single document. The contingency plan should be compatible and integrated with the pollution response, disaster, security, fire, and emergency plans of the local, state, and federal agencies involved. The contingency plan needs to be rehearsed regularly by conducting mock drills or tabletop exercises and using realistic scenarios to add some sense of practicality to the drill. Plans must be reviewed on a regular basis in order to respond to new or changing site conditions or information.

Personnel

This component of the plan includes not only onsite and offsite personnel with specific emergency-response roles but also others who may be onsite, such as contractors, other agency representatives, and visitors. Emergency personnel and their responsibilities are covered in detail as part of the overall organizational structure. This information is summarized in Table 12.2.

Table 12.2 Personnel Involved in Emergency Response

Project Team Leader

- Directs emergency response operations.
- Serves as liaison with appropriate government officials.

Site Safety Officer

- Recommends that work be stopped if any operation threatens worker or public health or safety.
- Knows emergency procedures, evacuation routes, and the appropriate telephone numbers including; ambulance, medical facility, poison control center, fire department, and police department.
- Notifies local public emergency officials.
- Provides for emergency medical care on site.

Command Post Supervisor

- Notifies emergency support personnel by telephone or radio in case rescue operations are required.
- Assists the Site Safety Officer in a rescue, if necessary.

Rescue Team

- An emergency rescue team stands by, partially dressed in protective gear, near the Exclusion Zone ready to rescue any workers whose health or safety is endangered.
- State emergency response personnel (varies among states).

Decontamination Station Officers

- Perform emergency decontamination.
- Ensures MSDS accompanies victim if needed.

Medical Team

- Transportation and treatment of victims by ambulance personnel, personnel at local clinics or hospitals, and physicians.
- Communication Personnel
- Local emergency service networks provide communication lines for mutual aid.
- Emergency management organizations and local radio and television stations provide information to the public during an emergency.

Environmental Scientists

- Predict the immediate and future movement of released hazardous substance through the geologic and hydrological environment and air.
- Assess the effect of this movement on groundwater quality, surface water quality, and air quality.
- Determine the probable movement of released toxic gases.

Table 12.2 Personnel Involved in Emergency Response (*continued*)

- Estimate the expected concentration of gases in the community and the expected duration of exposure.
- Predict the exposure levels of people and the ecosystem to the materials.

Hazardous Chemicals Experts

- Provide immediate advice to those at the scene of a chemical-related emergency.
- Use available references to assist Supervisors as needed.
- Perform testing and monitoring as required.

Firefighters

- Respond to fires that occur at a site; rescue victims.
- Perform other duties that the jurisdiction's fire department may provide: technical rescue, confined space rescue, etc.

Meteorologists

- Provide meteorological information needed by environmental scientists.
- Provide tide and currents if the incident is water related.

Public Safety Personnel

- The county sheriff, industrial security forces, the National Guard, and the police control site access, crowds, and traffic.
- Investigate any event that falls under their jurisdiction (accident, death, etc.)

Public Evacuation Personnel

- Emergency Management organizations plan evacuations.
- The National Guard and other military, the Red Cross, the Salvation Army, and municipal transportation systems mobilize transit equipment and assist in evacuations.

Emergency personnel may be deployed in a variety of ways. Depending on the nature and scope of the emergency, the size of the site, and the number of personnel, the emergency-response group can include individuals, small or large teams, or several interacting teams. Although deployment is determined on a site-by-site basis, significant general guidelines and recommendations are listed below. In all cases, the organizational structure should show a clear chain of command; every individual should know his or her position and authority, and the chain of command must be flexible enough to handle multiple emergencies, such as a rescue and a spill response, two rescues with a fire; or a spill response and two rescues.

The contingency plan should identify all individuals and teams that will participate in an emergency response and define their roles. All personnel, whether directly involved in emergency response or not, should know their responsibilities in an emergency. They must also know the names of those in authority and the extent of that authority.

Leader

In an emergency situation, only one person must be able to assume total control and decision making on- site. I think that everyone would agree with that concept. This leader must have the clear support of management and be authorized to seek and purchase supplies as necessary. Also, the leader must:

- Be identified in the emergency response plan; this person may be, for example, the Project Team Leader, Site Safety Officer, or Field Team Coordinator (or some other title)
- Be backed up by a specified alternate(s), also listed in the plan
- Have the authority to resolve all disputes about health and safety requirements and precautions
- Have control over activities of everyone entering the site: for example, contractors, visitors, and responding agencies

Teams

Although individuals (e.g., the Site Safety Officer) may perform certain tasks in emergencies, in most cases teams provide greater efficiency and safety. Teams composed of onsite personnel may be created for specific emergency purposes, such as decontamination, rescue, and entry. Rescue teams can be used during a particularly dangerous operation or at large sites with multiple work parties in the exclusion (hot) zone. Their sole function is to remain near hazardous work areas, partially dressed in protective gear, ready for full suiting (or fully suited, if appropriate) and immediate rescue of any endangered worker. These teams should be capable of administering cardiopulmonary resuscitation (CPR) and emergency first- aid treatment. Other teams can be formed, if needed, for responding to containment emergencies, confined- space emergencies, and firefighting until offsite assistance arrives.

Offsite Personnel

Offsite personnel may include individual experts such as meteorologists and toxicologists, often referred to as scientific support coordinators (see Table 12.2), and representatives of groups from local, state, and federal organizations offering rescue, response, or support (see Table 12.3 for a listing of typical organizations). As part of advanced planning, site personnel should:

- Make arrangements with individual experts to provide guidance as needed
- Make arrangements with the appropriate agencies (e.g., local fire department, state environmental agency, EPA regional office) for support
- Alert these authorities to the types of emergencies that may arise
- Determine their estimated response time and resources available from them

Table 12.3 Examples of Agencies and Groups Involved in Emergencies

AGENCY OR GROUP	RESCUE*	RESPONSE*	SUPPORT*
FEDERAL			
Army Corps of Engineers	x	x	x
Coast Guard	x	x	x
Department of Defense			x
Department of Transportation			x
Environmental Protection Agency (EPA)	x	x	x
Federal Aviation Administration (FAA)			x
Federal Emergency Management Agency (FEMA)		x	x
National Institute for Occupational Safety and Health (NIOSH)		x	
Occupational Safety and Health Administration (OSHA)			c
STATE			
Emergency Management Agency		b	c
Department of Health			c
Department of Labor			c
Environmental Agency		b	c
Office of the Attorney General			c
State Police	a	b	c
LOCAL			
Ambulance and Rescue Services	a	b	
Cleanup Contractor(s)			c
Disposal Companies			c
City/Town Manager/Administrator			
Fire Department	a	b	c
Hospital			c
Police	a	b	c
Red Cross			c
Salvation Army			c
Transporters			c
Utility Companies (electric, gas, water, phone)		b	

a Rescue = extricating and/or providing on-the-spot emergency treatment to victims.
b Response = controlling and stabilizing hazardous conditions.
c Support = providing technical assistance, equipment, and/or resources.

- Identify backup facilities, if needed
- Provide training and information about specific hazards onsite and special procedures for handling them
- Establish a contact person and means of notification at each agency

FEDERAL RESPONSE ORGANIZATIONS

Site emergencies involving significant chemical releases should be coordinated with federal response organizations. The federal government has established a National Contingency Plan (NCP) to promote the coordination and direction of federal and state response systems and to encourage the development of local government and provide capabilities to handle emergencies involving chemical releases.

To implement the NCP, a national organization was established, including a National Response Team (NRT), a network of Regional Response Teams (RRTs), a group of On-Scene Coordinators (OSCs), and a National Response Center (NRC). The National Response Center is the national terminal point for receipt of notification of significant chemical release, and the OSCs are the interface between the onsite personnel and the federal response organizations (usually EPA or the USCG). The OSC is the federal official responsible for ensuring that necessary response actions are taken to protect the public and the environment from the effects of a chemical release. Many federal agencies have specific technical expertise available to assist the OSC. Table 12.4 lists some of the agencies that may assist in the event that they are needed.

Table 12.4 Federal Agencies That May Assist in Emergencies

AGENCY	ASSISTANCE
Department of Homeland Security	Various, terrorist related, and USCG assistance
Department of Defense	Various, equipment, troops, etc.
Federal Railroad Administration	Regulatory guidance and familiarization
Occupational Safety and Health Administration	Safety compliance and inspections
U.S. Army Corps of Engineers	Permits, engineering
Department of Transportation	Various, hazmat compliance, etc.
National Oceanic and Atmospheric Administration	Vessels, weather information, tide and currents, etc.
Federal Aviation Administration	Flight information, air space restrictions, etc.

If a significant chemical release occurs at a hazardous-waste site, the National Response Center in Washington, D.C., should be contacted (Telephone: (800) 424-8802). The National Response Center will activate federal response under the National Contingency Plan if it is needed.

TRAINING

Since immediate, informed response is essential in an emergency, all site personnel and others entering the site (visitors, contractors, offsite response groups, other agency representatives) must have some level of emergency training. The level and extent of training will ultimately depend on the responder's role and how close to the contaminant he/she will get. Any training program should:

- Relate directly to site-specific, anticipated situations
- Be brief and repeated often
- Be realistic and practical
- Provide an opportunity for special skills to be practiced regularly
- Feature frequent drills (e.g., site-specific, mock rescue operations)
- Ensure that training records are maintained in a training logbook or other suitable place

Everyone entering the site must be made aware of the hazards and of unsafe actions that are forbidden or should be avoided (e.g., smoking, firearms, drugs, alcohol). They must also know what to do in case of an emergency. All visitors should be briefed on basic emergency procedures such as decontamination, emergency and alarm signals, and evacuation routes and rally points.

Personnel without defined emergency response roles (e.g., contractors, some federal agency representatives) must still receive a level of training that includes at a minimum:

- Hazard recognition
- Standard operating procedures
- Signaling an emergency: the alarm used, how to summon help, what information to give, and who to give it to
- Evacuation routes and shelters
- The person to report to when an alarm sounds

Onsite emergency personnel, who have emergency roles in addition to their ordinary duties, must have a thorough understanding of emergency response. Training should be directly related to their specific roles and should include subjects such as:

- Emergency chain-of-command
- Communication methods and signals (alarms)
- How and where to call for help
- Emergency equipment, locations, and use
- Emergency evacuation while wearing protective equipment
- Removing injured personnel from confined spaces
- Offsite support and how to use it

Offsite emergency personnel such as local firefighters and ambulance crews often are first responders and run a risk of acute hazard exposure equal to that of any onsite worker. These individuals should be informed of ways to recognize and deal effectively with onsite hazards. Lack of information may inadvertently worsen an emergency by improper actions (e.g., spraying water on a water-reactive chemical and causing an explosion). Inadequate knowledge of the onsite emergency chain –of command may cause confusion and delays. Site management should at a minimum provide offsite emergency personnel with information about:

- Site-specific hazards
- Appropriate response techniques
- Site emergency procedures
- Decontamination procedures

EMERGENCY RECOGNITION AND PREVENTION

On a day-to-day basis, individuals should be constantly alert for indicators of potentially hazardous situations and for signs and symptoms in themselves and others that warn of hazardous conditions and exposures. Rapid recognition of dangerous situations can avert an emergency. Before daily work assignments, regular "tailgate safety meetings" should be held. Discussion should include:

- Specific tasks to be performed
- Time constraints (e.g., rest breaks, air tank changes, tide restrictions)
- Hazards that may be encountered, including their effects, how to recognize symptoms or monitor them, concentration limits, or other danger signals
- Emergency procedures

After daily work assignments, a debriefing session should be held to review all work accomplished, and any problems observed can be discussed at this time. It is from these daily sessions that modifications to the work and safety plan can be made if needed. It also gives the workers a chance to let the supervisors know about any areas that may be causing problems that they might not have seen. The workers act as the eyes and ears of the supervisors, as the supervisors can't be everywhere.

COMMUNICATIONS

In an emergency, crucial messages must be conveyed quickly and accurately. Site staff must be able to communicate information such as the location of injured personnel, orders to evacuate the site, and notice of blocked evacuation routes even through noise and confusion. Outside support sources must be reached, help obtained, and measures for public notification ensured if necessary. To do this, a separate set of internal emergency signals should be developed and rehearsed periodically. External communication systems and procedures should be clear and accessible to all workers.

Internal Communications

Internal emergency communication systems are used to alert workers to danger, convey safety information, and maintain site control. Any effective system or combination may be employed. Radios or cellular telephones are often used when work teams are far from the command post. Alarms or short, clear messages can be conveyed by audible signals such as bullhorns, megaphones, sirens, bells, and whistles or by visual signals such as colored flags, lights, and hand or whole-body movements. The primary system must have a backup. For example, hand signals may be used as a backup if radio communications fail. All internal systems should be:

- Clearly understood by all personnel
- Checked and practiced daily
- Intrinsically safe (spark-free)

A special set of emergency signals should be set up. These should be:

- Different from ordinary signals
- Brief and exact
- Limited in number so that they are easily remembered

Examples include signals for stop, evacuate, help, and all clear. Any set of signals may be used to convey these messages as long as all personnel understand their meaning. Table 12.5 gives some examples for devices.

Managers should consider devices and equipment used in the exclusion (hot) and contamination- reduction (warm) zones that are intrinsically safe and not capable of sparking if the potential is there for a fire or explosion. Radio and cell-phone manufacturers can tell you if their product is intrinsically safe. Pagers and other devices

Table 12.5 Sample Internal Emergency Communication Signals

DEVICES' AND SIGNALS	EXAMPLE
Radio (citizen's band or FM)	Established Code Words
Noisemakers, including: Bell Compressed air horn Megaphone Siren Whistle	*One Long Blast*: Evacuate area by nearest emergency exit *Two short blasts*: Localized problem (not dangerous to workers). Two long Blasts: All clear.
Visual signal, including: Hand Signals Whole body movements Hand clutching throat	Out of air/can=t breath
Hand on top of head	Need assistance
Thumbs Up	OK/I=m alright/I understand
Thumbs Down	No/Negative
Grip partner's wrist or both hands around partner's waist.	Leave area immediately

should also be checked before being allowed in these areas. (Recently, cell-phone manufacturers have added a camera feature to many cellular phones. Site management is wise to have a policy in place regarding their use at the site, especially in work zones. I worked at a site recently that allowed no personal cellular phones and no digital cameras except for supervisors.)

When designing and practicing communication systems, remember that:

- Background noise onsite will interfere with talking and listening
- Wearing personal protective equipment will impede hearing and limit vision (e.g., the ability to recognize hand and body signals)
- Inexperienced radio users may need practice in speaking clearly
- Speak in English: no codes, no slang, no curse words
- Have a communications list with accurate contact numbers
- Be careful of the vibration mode—it startles some users
- Have spare batteries and chargers available
- Ensure that adequate cellular coverage is in the area

- Make sure that you have the area code(s) for the people you are calling
- Use of hands-free devices is becoming law in some areas
- Limit use of cellular phone and radio while operating heavy equipment or motor vehicles

External Communications

Offsite sources often need to be contacted to obtain assistance or to inform officials about hazardous conditions that may affect public or environmental safety. The telephone is the most common mode of offsite communication; phone hookups are considered a necessity at all but the most remote sites. (This won't be the case for the small job that is scheduled to last a day or so,(e.g., a tank removal). For the long-term projects, a phone is a necessity.)

Some guidelines to be followed include:

- The National Response Center (Telephone: (800) 424-8802) should be contacted in the event of a significant chemical release. The National Response Center will contact the appropriate Federal On-Scene Coordinator (FOSC).
- All personnel must be familiar with the protocol (phone number or emergency code, contact person) for contacting public emergency-aid teams such as fire departments, ambulance or rescue units, and hospitals. If you are at a facility, you may have to dial 8 or 9 to get an outside line. Know how your phone system works before you need to make an emergency phone call.
- If there is no site telephone system, all personnel must know the location of the nearest public telephone. A supply of telephone change and the necessary phone numbers must be readily available.

SITE MAPPING

Detailed information about the site is essential for advanced planning. For this purpose, a site map is a valuable tool. It serves as a graphic record of the locations and types of hazards, a reference source, and a method of documentation. This map can be a duplicate of the one developed for the site safety plan, but it should focus on potential areas where emergencies may develop. Pins and colored flags can be used to mark changes in personnel deployment, hazard areas, and equipment locations. The map should highlight:

- Hazard areas, especially potential IDLH conditions
- Site terrain: topography, buildings, barriers
- Evacuation routes
- Site accessibility by land, water, and air

- Work-crew locations
- Changes (e.g., work activities, vandalism, accidents)
- Offsite populations or environmentally sensitive areas at potential risk

The map can be used for planning as well as training. It can serve as a basis for developing potential emergency scenarios and alternative response strategies. When an emergency occurs, the problem should be pinpointed on the map. Pertinent information such as weather and wind conditions, temperature, and forecast should be added. The map can then be used to design the emergency plan—e.g., to define zones; determine evacuation routes; and identify emergency first-aid, decontamination, and command post stations. When using the map for such purposes, the accuracy of the data obtained and the potential for over- or underestimating a hazard should be considered.

Even if the emergency develops so fast that the map cannot be used for on-the-spot planning, prior familiarity with it will assist in making informed decisions.

SAFE DISTANCES AND REFUGES

No single recommendation can be given for evacuation or safe distances because of the wide variety of hazardous substances and releases found at sites. For example, a "small" chlorine leak may call for an isolation distance of only 140 feet (43 meters), while a "large" leak may require an evacuation distance of 1 mile (1.6 kilometers) or more, depending on the wind direction and the surrounding area. The refuge (shelter) should never be used for activities such as eating, drinking, or air-cylinder changes. Typical items located in a refuge area include:

- A sitting/resting area that should be shaded if possible
- Water for decontamination and for drinking purposes
- Wind indicator
- Communication system with the command post
- First-aid supplies—e.g., eyewash, first-aid kit, blanket, etc.
- Special monitoring devices—e.g., extra detector tubes and personal monitors
- Bolt cutters
- Fire extinguishers
- Small hand tools

Other shelters can be set up in the support (cold) zone or, in the case of site-wide evacuation, offsite at a safe exit destination. These will provide for emergency needs such as first aid for injured personnel; clean, dry clothing; wash and rinse water for chemical exposure victims; and communications with command post. In a large area evacuation, they can be used to house evacuation equipment, thereby reducing security problems. These refuges should be stocked with such items as:

- Decontamination supplies
- Oxygen and/or breathing air
- Drinking water
- Special testing equipment (pH paper and air monitors)
- First-aid supplies
- Communications equipment

SITE SECURITY AND CONTROL

In an emergency, the Project Team Leader (or designated representative) must know who is onsite and must be able to control the entry of personnel into the hazardous areas to prevent additional injury and exposure. Only necessary rescue and response personnel should be allowed into the hot zone.

One control technique is a checkpoint or series of checkpoints through which all personnel entering or exiting the site must pass—for example, a cold zone checkpoint and a hot zone checkpoint. Identification or authorization must be presented to a checkpoint control person, who records each person's:

- Name (and affiliation if offsite personnel)
- Status (in or out)
- Time of entry
- Anticipated exit time
- Zones or areas to be entered
- Team members or "buddy"
- Task being performed
- Location of task
- Protective equipment worn and air time left
- Rescue and response equipment used

The emergency-area checkpoint-control person should inform the Project Team Leader if a person remains in the emergency area beyond his or her anticipated exit time.

PERSONAL LOCATOR SYSTEMS

In an emergency, it is vital for the Project Team Leader (or designee) and rescue personnel to quickly determine where workers are located and who may be injured or incapacitated. A passive locator system (i.e., a written record of the location of all personnel onsite at any time) could be used to help find personnel in an emergency. Any such system should be:

- Graphic (such as a drawing with a written key)
- Roughly drawn to scale, with the scale and visible landmarks included
- Kept current
- Easy to locate
- Stored outside the exclusion zone

A good passive locator system is a site map with flags or color-headed pins identifying each worker or work area. Active locator systems can also be used. These are worn or carried by individual personnel and are activated by actions such as flipping a switch, a decrease in air supply, or a fall. They have the advantage of precisely locating individuals.

Figure 12.2 This special alarm worn on the firefighter's bunker gear or worker's PPE is activated by the wearer as soon as he arrives at the fire scene/site. The P.A.S.S. alarm contains a motion detector. Should the firefighter/worker become trapped or overcome and remain motionless for a short period of time the P.A.S.S. alarm goes off making a loud noise for other workers in the area to hear and come to his/her rescue. The P.A.S.S. alarm can also be manually set off by the wearer if he/she gets in trouble.

EVACUATION ROUTES AND PROCEDURES

A severe emergency, such as a fire or explosion, may cut workers off from the normal exit near the command post. Therefore, alternate routes for evacuating victims and endangered personnel should be established in advance, marked, and kept clear at all times. Routes should be directed (1) from the hot zone through an upwind warm zone to the cold zone and (2) from the cold zone to a safe offsite location in case conditions warrant a total site evacuation. The following guidelines will help in establishing safe evacuation routes.

- Place the evacuation routes in the predominantly upwind direction of the hot zone. (At a very large site or one with many obstacles, some exits may be placed in the downwind fence line, normally an undesirable location. If this is done, workers must know that they are not "out" until they reach the designated safety area. Workers should be advised of this situation in daily safety briefings.)
- Run the evacuation routes through the warm zone. Even if there is not enough time to process the evacuees through decontamination procedures, there should at least be a mechanism for accounting for all personnel in this area, even if it means just taking names.
- Consider the accessibility of possible routes. Take into account obstructions such as locked gates, trenches, pits, tanks, drums, or other barriers and the extra time or equipment needed to maneuver around or through them.

- Develop two or more routes that lead to safe areas and that are separate or remote from each other. Multiple routes are necessary in case one is blocked by a fire, spill, or toxic cloud. These routes must not overlap because, if a common point were obstructed by a fire or other emergency, all intersecting routes would be blocked.
- Mark routes "safe" or "not safe" on a daily basis according to wind direction and other factors. This can be done with color-coded flags or signs.
- Mark evacuation routes with materials such as barricade tape, flagging, or traffic cones. It is equally important to mark areas that do not offer safe escape or that should not be used in an emergency, such as low ground, which can fill with gases or vapors, or routes blocked by natural barriers, such as cliffs or streams.
- Consider the mobility constraints of personnel wearing protective clothing and equipment. They will have difficulty crossing even small streams and going up and down hills or difficult terrain.
- Place ladders across any cut or excavation that is more than 3 feet (1 meter) deep. For long cuts, place ladders at least every 25 feet (7.5 meters), and for deep cuts, place plywood or planks on top of ladders. If at all possible, avoid excavations altogether.
- Provide ladders for rapid descent from areas or structures elevated more than 3 feet (1 meter).
- Use only ladders capable of supporting at least a 250-pound load.
- Place ramps across ditches and other similar obstacles. Add a railing and toe boards if the board is narrow or steeply sloped.
- Check the toe and body clearance of ladders to make sure that personnel wearing protective clothing and respiratory protection, especially breathing apparatus, can use them.
- Check the clearance of access ports, such as crawlspaces, hatches, manholes, and tunnels, to make sure that personnel wearing a protective ensemble can get through. In any case, access ports should be at least 3 feet (1 meter) in diameter where possible. (Standard tank openings are often smaller.)
- Make escape routes known to all who go onsite by including information in the safety plan and stressing the routes in daily safety briefings.

DECONTAMINATION

When planning for decontamination in medical emergencies, procedures should be developed well in advance for:

- Decontaminating the victim
- Protecting the responding medical personnel and hospital personnel if applicable
- Disposing of all contaminated protective equipment and wash solutions

These activities should be coordinated with responding agencies or any other party that may be involved, such as the hospital or ambulance company. The decision whether or not to decontaminate a victim is based on the type and severity of the illness or injury and the nature of the contaminant involved and will likely be made by the medical-response personnel or first-aid team. For some emergency victims, immediate decontamination may be an essential part of life-saving first aid efforts. For others, decontamination may aggravate the injury or delay lifesaving emergency treatment. If decontamination does not interfere with essential treatment, it should be performed prior to treating or transporting the victim.

If decontamination can be done, the following steps should be followed:

- Wash
- Rinse and/or
- Cut off/remove protective clothing and equipment safely
- Dispose of clothing properly

If decontamination cannot be done, then the following steps are recommended:

- Wrap the victim in blankets, plastic, or rubber to reduce contamination of other personnel and medical treatment areas
- Get victim to clean area as soon as possible to be treated by professional medical response staff

Emergency and offsite medical personnel should be alerted to any potential contamination; instruct them about specific decontamination procedures if necessary. Send along site personnel familiar with the incident in the event that technical questions need to be answered and so the victim has a person who can notify family members, etc. If appropriate (and it is always appropriate if a chemical exposure is involved) a material -safety data sheet should also accompany the patient to the medical-treatment location (hospital, walk-in clinic, doctor's office, etc.).

EQUIPMENT

In an emergency, specialized equipment may be necessary to rescue and treat victims, to protect response personnel, and to mitigate hazardous conditions on the site (e.g., to contain chemicals or fight fires). Some "regular" equipment can double for emergency use. Because of its high cost, most heavy equipment (e.g., bulldozers, Bobcats, excavators, loaders) employed in emergencies will also be used for regular work assignments. All equipment should be in good working order, fueled, and available when an emergency occurs. Safe and unobstructed access for all firefighting and emergency equipment must be provided at all times. It is not appropriate to park in an area designated for emergency vehicles, even for a minute. Site management might consider adopting the following work procedures:

- Refuel all heavy equipment when there is still one-half to one-quarter of a tank of fuel left
- Require all equipment repairs to take place at the time the problem is discovered
- Refill all empty self-contained breathing apparatus (SCBA) tanks and prepare them for emergencies immediately after normal or emergency use
- Stock a higher level of protective equipment than what is typically required for anticipated hazards (e.g., in a site where Level C equipment is normally used try to have Level A and/or B equipment available for emergencies) so that personnel are protected in the event that unknown materials are involved

Basic equipment that should be available at any site is listed in Table 12.6. Special equipment should be obtained depending on the specific types of emergencies that may occur at a particular site and the capabilities of backup offsite personnel. As an example, if the nearest fire department is rural or volunteer and only carries one container of foam solution because of its high cost and short shelf life, the site may need to stock a larger quantity of foam if there is a likelihood that it may be needed.

When determining the type and quantity of special equipment, the following factors should be considered when planning for emergencies:

- The types of emergencies that may arise—for each emergency, consider a probable and a worst-case scenario
- The types of hazards that site personnel may be exposed to and the appropriate containment, mitigation, and protective measures
- The number of site personnel who could be victims during an emergency situation
- The probable number of personnel available for emergency response (both on- and offsite)

MEDICAL TREATMENT AND FIRST AID

In emergencies, toxic exposures and hazardous situations that cause injuries and illnesses will vary from site to site. Medical treatment may range from applying a bandage to a minor cut or abrasion to lifesaving techniques, such as administering cardiopulmonary resuscitation (CPR) or using an automatic external defibrillator (AED). During many emergencies, essential medical help may not be immediately available. For this reason, it is extremely important to have emergency personnel (onsite) trained in on-the-spot treatment techniques who can establish and maintain telephone contact with medical experts (e.g., industrial hygienists, toxicologists, and doctors) and with local hospitals and ambulance services. When designing this program, these essential points should be included:

Table 12.6 Onsite Equipment and Supplies for Emergency Response

PERSONAL PROTECTION	MEDICAL	HAZARD MITIGATION
Escape SCBA or SCBA, which can be brought to the victim to replace or supplement his or her SCBA.	Air Splints	Firefighting equipment and supplies.
Personal protective equipment and clothing specialized for known site hazards.	Antiseptics	Spill-containment equipment, such as adsorbents and oil booms.
	Blankets	Special hazardous-use tools such as remote pneumatic impact wrenches, nonsparking wrenches and picks.
	Decontamination solutions appropriate for onsite chemical hazards	Containers to hold contaminated materials.
	Emergency Eye Wash	
	Emergency showers or wash stations	
	Ice	
	Reference books containing basic first-aid procedures and information on treatment of specific chemical injuries	
	Safety harness	
	Stretcher	
	Water, in portable containers	
	Wire basket litter (Strokes litter) which can be used to carry a victim in bad weather and over difficult terrain, allows easy decontamination of the victim, and is itself easy to decontaminate.	

- Train a group of personnel in emergency treatment such as first aid and CPR. One person is generally not enough. Training should be thorough, frequently repeated, and geared to site-specific hazards.
- Establish liaisons with local medical personnel, including 24-hour on-call physicians, medical specialists, local hospitals, ambulance or rescue services, and local poison- control centers. Notify and educate these personnel about site-specific hazards so that they can be more helpful if an emergency does occur. Procedures for contacting these specialists should be developed and all onsite emergency personnel should be familiar with these procedures. (Contact information could be placed in the safety plan for ease in locating the numbers.)
- Set up onsite emergency first-aid stations; see that they are well supplied, checked periodically, and restocked immediately after each emergency.

EMERGENCY RESPONSE PROCEDURES

Response operations usually follow a sequence that starts with the notification of a problem and continues through the preparation of equipment and personnel for the next emergency incident.

Figure 12.3 An eyewash station is strategically placed, so that in the event it is needed, workers will not have to travel far for it.

To alert personnel in the event of an emergency, an alarm should be sounded to:

- Notify personnel
- Stop work activities if necessary
- Lower background noise in order to speed communication
- Begin emergency procedures

When onsite emergency-response personnel are notified about an emergency, the notification should include essential information (if known), such as:

- What happened
- Where it happened
- Whom it happened to
- When it happened
- How it happened
- The extent of damage and number of people involved
- What assistance is needed

Size-Up

Available information about the incident and emergency-response capabilities should be evaluated. The following information should be determined, to the extent possible:

- Is there sufficient help?
- Is anyone's life endangered right now?
- Can emergency personnel gain entry to the area safely?
- What is the extent of chemical release and environmental concerns?
- Will there be a need for ventilation or air supply?
- Is there a potential for a fire or explosion?
- Safety— always

Rescue/Response Action

Based on the available information, the type of action required should be decided and the necessary steps implemented. Some actions may be done concurrently. No one should attempt emergency response or rescue until backup personnel and evacuation routes have been identified. Rescue/response actions may include the following:

- Enforcement of the buddy system: No one is allowed to enter a hot zone or hazardous area without a partner. There are no exceptions to this rule. At all times, personnel in the hot zone should be in the line –of sight of or have communications contact with the Command Post Supervisor or designee.
- Locate all victims and assess their condition as soon as possible.
- Determine any resources that may be needed for stabilization and transport to the nearest medical facility capable of handling the situation.
- Assess existing and potential hazards to site personnel and to the offsite population.
- Determine whether and how to respond.
- Determine if it is necessary to evacuate the site personnel and/or offsite population.
- Decide if the resources needed for evacuation and response are available.
- Allocate onsite personnel and equipment to rescue and incident-response operations.
- Contact the required offsite personnel or facilities, such as the ambulance, fire department, and police.
- Bring the hazardous situation under complete or temporary control; use measures to prevent the spread of the emergency.
- Remove or assist victims from the area.
- Use established procedures to decontaminate uninjured personnel in the contamination-reduction (warm) zone. If the emergency makes this area unsafe, establish a new decontamination area at an appropriate location. Decontaminate victims before or after stabilization as their medical condition indicates.
- Administer any medical procedures that are necessary before the victim(s) can be moved. Stabilize or permanently fix the hazardous condition. Attend to what caused the emergency and anything (e.g., drums, tanks) damaged or endangered by the emergency if safe to do so.
- Take measures to minimize chemical contamination of the transport-vehicle, ambulance, and hospital personnel. (The use of plastic helps in this quite well.) If this is not possible, cover the victims with adequate sheeting. Before transportation, determine the level of protection necessary to transport personnel. Provide the transportation unit with disposal coveralls and disposable gloves, as necessary, for their protection. If appropriate, have response personnel accompany victims to the medical facility to advise on decontamination. Provide MSDS as appropriate.
- Move site personnel to a safe distance upwind of the incident.
- Monitor the incident for significant changes. The hazards may diminish, permitting personnel to reenter the site, or increase and require public evacuation.
- Advise public-safety personnel if there is a potential or actual need to evacuate the offsite population. Do not attempt large-scale public evacuation. This is the responsibility of government authorities.

Follow-Up Procedures

Before normal work activities are resumed, the safety officer, with input from site management, needs to give the approval. Personnel must be fully prepared and equipped to handle another emergency (should one occur); equipment should be restocked; the cause of the incident should be established and corrected; and any other loose ends taken care of before work commences. Some of the items to consider include:

- Notify appropriate government agencies as required—for example, National Response Center, state environmental agencies, OSHA (if applicable), etc.
- Restock all equipment and supplies. Replace or repair damaged equipment. Clean and refuel equipment for future use.
- Review and revise all aspects of the contingency plan according to new site conditions and lessons learned from the emergency response. (Typical review questions are shown in Table 12.7.)

Table 12.7 Typical Review Questions

Cause: What caused the emergency?
Prevention: Was it preventable? If so, how?
Procedures: Were inadequate or incorrect orders given or actions taken? Were these the result of bad judgment, incorrect or insufficient information, or poor procedures? Can procedures or training be improved?
Site profile: How does the incident affect the site profile? How are other site cleanup activities affected?
Liability: Who is legally responsible for damage payments?

Documentation

The Project Team Leader or designee should initiate the investigation and documentation of the emergency incident. This is important in all cases, but especially so when the incident has resulted in any personal injury or death, onsite or offsite property damage, or damage to the surrounding environment. Documentation may be used to help avert recurrences, as evidence in future legal actions, for assessment of liability by insurance companies, for review by government agencies, and as a "lessons learned" activity. Methods of documenting can include a written transcript taken from tape (audio or video) recordings made during the emergency or a bound field book (preferably not a looseleaf book) with notes or any other written notations. The document must be:

- Accurate: All information must be recorded objectively.
- Authentic: A chain-of-custody procedure should be used. Each person making an entry must date and sign the document. Keep the number of documenters to a minimum (to avoid confusion and because they may have to give testimony at hearings or in court). Nothing should be erased. If details change or revisions are needed, the person making the notation should mark a horizontal line through the old material and initial and date the change(s).
- Complete: It should be a thorough depiction of the activities that took place.

Each situation will be different, however, and, at a minimum, the following information should be included:

- Chronological history of the incident
- Facts about the incident if and when they became available
- Title and names of personnel; composition of teams
- Action: decisions made and by whom; orders given: to whom, by whom, and when; and actions taken: who did what, when, where, and how
- Types of samples and test results such as air monitoring results
- Possible exposures of site personnel
- History of all injuries or illnesses during or as a result of the emergency.

Emergency Response Plan

It is important to know what your roles and responsibilities are in the event of an emergency. Employers are required to have a written emergency-response plan to handle any anticipated emergency and to put the plan into practice before operations begin.

An emergency-response plan must address:

- Pre-emergency planning
- Personnel roles and lines of authority
- Site layout and typical weather patterns for the given area
- Site-security and control measures
- Emergency recognition and prevention
- Emergency alerting and response procedures
- Safe distances
- Evacuation routes and procedures
- Emergency decontamination procedures
- Emergency medical treatment and first aid
- Incident reporting to various agencies
- Compatibility with federal, state, and local plans

Table 12.8 Exposure Sheet

SAMPLE TYPE:______________________________ SAMPLE ID#_______________

____

____

____

LOCATION WHERE SAMPLE WAS COLLECTED:

NORTH_____ SOUTH_____ EAST_____ WEST_____

FILE #_______________

TIME SAMPLE COLLECTED:____________

DATE SAMPLE COLLECTED:____________

SAMPLE TAKEN BY: ___________________

LAB SAMPLES SENT TO: __________________________

Table 12.9 Air Monitoring Log

Test Results								
Tests Required			Safe Limits	Time ° Results	Time ° Results	Time ° Results	Time ° Results	Time ° Results
O_2	Yes		19.5-23.5%	°	°	°	°	°
Combustibles	Yes		< 10% LEL	°	°	°	°	°
Toxics	Yes	No	°	°	°	°	°	°
H_2S	°	°	< 10 ppm	°	°	°	°	°
CO	°	°	< 25 ppm	°	°	°	°	°
Others:	°	°	°	°	°	°	°	°
°	°	°	°	°	°	°	°	°
°	°	°	°	°	°	°	°	°

- Evaluation of emergency response and follow-up
- Review plan periodically

SUMMARY

Emergency response to hazardous-material incidents is a unique task and can be extremely complex. All site personnel need to have a firm understanding of the topical areas that we covered in this section. It's not enough to know your role and responsibilities if you don't understand the entire plan or know what agencies may have jurisdiction at the site in the event of an emergency release.

Workers will have to be trained and shown where the emergency tools and equipment are located. Frequent drills or practice sessions can help prevent the panic that so often prevails when an emergency occurs. Involvement with outside agencies and contractors also helps to alleviate problems when the real thing happens.

GLOSSARY

Accident: An unexpected event generally resulting in injury, loss of property, or disruption of service.

Action level: A quantitative limit of a chemical, biological, or radiological agent at which actions are taken to prevent or reduce exposure or contact.

Acute exposure: A dose that is delivered to the body in a single event or in a short period of time.

Air-quality standards: The maximum limits or concentrations of pollutants permitted in air. United States standards are based on estimates of maximum concentrations that, with an allowance for safety, present no harm to human health or the environment.

Ambient-air guidelines: Air-quality criteria incorporated in some state programs used to evaluate the acceptability of a source's impact. Guidelines differ from standards in that other factors can also be incorporated into the evaluation.

Aquifer: A saturated water-bearing formation of permeable rock, sand, or gravel.

Chronic cxposure: Low doses repeatedly received by the body over a long period of time.

Contaminant/contamination: An unwanted and nonbeneficial substance.

Criteria pollutant: One of six air pollutants for which a National Ambient Air Quality Standard (NAAQS) has been established by EPA: sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, particulate matter (smaller than 10 microns in diameter or PM-10), and lead. NAAQS has been established based on specific health criteria.

Decontamination: The process of removing contaminants from individuals and equipment.

Degree of hazard: A relative measure of how much harm a substance can do.

Direct-reading instrument: A portable device that measures and displays, in a short period of time, the concentration of a contaminant in the environment.

Emergency: A sudden and unexpected event calling for immediate remedial action.

Emission standard: The maximum amount of a specified pollutant permitted in airborne discharges.

Environmental assessment: The measurement of prediction of the transport, dispersion, and final location of a released hazardous substance.

Environmental hazard: A condition capable of posing an unreasonable risk to air, water, or soil quality and to plants or wildlife.

EPA: The Environmental Protection Agency, an independent federal agency of the United States government, established in 1970, that is responsible for dealing with the pollution of air, water, and soil by solid waste, pesticides, and radiation and with nuisances caused by noise.

Episode: Incident.

First responder: The first trained personnel to arrive on the scene of a hazardous-material incident. Usually officials from local emergency services, firefighters, and police.

GEP: Good engineering practice.

Groundwater: Water in a saturated zone or formation beneath the surface of land or water.

Hazard: A circumstance or condition that can do harm. Hazards are categorized into four groups: biological, chemical, radiation, and physical.

Hazard classes: A series of nine descriptive terms that have been established by the UN Committee of Experts to categorize the hazardous nature of chemical, physical, and biological materials. These categories are flammable liquids, explosives, gases, oxidizers, radioactive materials, corrosives, flammable solids, poisonous and infectious substances, and dangerous substances.

Hazard evaluation: The impact or risk a hazardous substance poses to public health and the environment.

Hazardous: Capable of posing an unreasonable risk to health and safety (Department of Transportation); capable of doing harm.

Hazardous material: A substance or material that has been determined by the Secretary of Transportation (or by the Department?] to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce and has been so designated.

Hazardous sample: Sample that is considered to contain a high concentration of contaminants.

Hazardous substance: A material and its mixtures or solutions that is identified by the letter "E" in Column (1) of the Hazardous Materials Table, CFR 49, Sec. 172.101, when offered for transportation in one package, or in a transport vehicle if not package, and when the quantity of the material therein equals or exceeds the reportable quantity. Also, any substance designated pursuant to Section 311 (b)(2)(A) of the Federal Water Pollution Control Act; any element, compound, mixture, solution, or substance designated pursuant to Section 102 of this Act; any hazardous waste having the characteristics identified under or listed pursuant to Section 3001 of the Solid Waste Disposal Act (but not including any waste the regulation of which under the Solid Waste Disposal Act has been suspended by Act of Congress); any toxic pollutant listed under Section 307(a) of the Federal Water Pollution Control Act; any hazardous air pollutant listed under Section 112 of the Clean Air Act; and any imminently hazardous chemical substance or mixture with respect to which the Administrator has taken action pursuant to Section 7 of the Toxic Substances Control Act. The term does not include petroleum, including crude oil, or any material thatis not otherwise specifically listed or designated as a hazardous substance in the Federal Water Pollution Control Act, nor does it include natural gas, natural-gas liquids, liquefied natural gas, or synthetic gas usable for fuel (of mixtures of natural gas and synthetic gas).

Hazardous waste: Waste that contains any substance harmful to life. It may be toxic (such as pesticides, compounds of arsenic, cyanides), flammable (such as hydrocarbons), corrosive (strong acids are alkalis), or oxidizing (such as nitrates or chromates). Some may be hazardous on more than one count. Also, any material that is subject to the hazardous-waste manifest requirements of the Environmental Protection Agency specified in the CFR, Title 40, Part 62 or would be subject to these requirements in the absence of an interim authorization to a State under Title 40, CFR, Part 123, Subpart F.

IDLH: Immediate danger to life and health, the level that represents a maximum concentration from which one could escape within 30 minutes without any escape-impairing symptoms or irreversible health effects. These include substances that should be treated as potential human carcinogens.

Immediate removal: Actions undertaken to prevent or mitigate immediate and significant risk of harm to human life or health or to the environment. As set forth in the National Contingency Plan, these actions shall be terminated after $1 million has been obligated or six months have elapsed from the date of initial response.

Incident: The release or potential release of a hazardous substance into the environment.

Incident characterization: The process of identifying the substance(s) involved in an incident, determining exposure pathways, and projecting the effect it will have on people, property, wildlife and plants, and the disruption of services.

Incident evaluation: The process of assessing the impact released or potentially released substances pose to public health and the environment.

Information: Knowledge acquired concerning the conditions or circumstances particular to an incident.

Inspection: See investigation.

Intelligence: Information obtained from existing records or documentation, placards, labels, signs, special configuration of containers, visual observations, technical records, eye witnesses, and others.

Investigation: A formal examination or study.

LAER: Lowest achievable emission rate, required for new or modified major sources located in nonattainment areas. LAER is based on the most stringent emission rate contained in any state implementation plan or achieved in practice by the same and smaller sources.

Limited quantity: With the exception of Poison B materials, the maximum amount of a hazardous material for which there is a specific labeling and packaging exception.

Mitigation: Actions taken to prevent or reduce the severity of harm.

Monitoring: The process of measuring certain environmental parameters on a real-time basis for spatial and time variations. For example, air monitoring may be conducted with direct-reading instruments to indicate relative changes in air-contaminant concentrations at various times.

NA: Nonattainment area, an air-quality -ontrol region (or portion thereof) in which the EPA has determined that ambient-air concentrations exceed NAAQS for one or more criteria pollutants.

NAAQS: National Ambient Air Quality Standards, air-quality standards established by the Clean Air Act intended to protect public health and welfare. Substances for which NAAQS are established are called "criteria pollutants."

National contingency plan: Policies and procedures that the federal government follows in implementing responses to hazardous substances.

NESHAP: National emission standards for hazardous pollutants, a set of national emission standards for listed hazardous pollutants (carcinogens, mutagens, toxicants, etc.) emitted from specific classes or categories of new and existing sources. These were introduced in the Clean Air Act Amendments of 1977.

NSPS: New-source performance standards, a set of national emission standards for both criteria and designated pollutants from specific classes or categories of new, modified, or restructured sources. For the last ten years, NSPS have been the bedrock of air-pollution-control strategy.

OEL: Occupational exposure levels, a general description for permissible occupational exposure levels set by occupational-health agencies. OEL are often used as a basis for developing ambient-air guidelines for toxic-air programs.

Offsite: Presence outside the work site.

Onsite: Presence within the boundaries of the work site.

OSHA: Occupational Safety and Health Administration (agency under the Department of Labor).

Pathways of dispersion: The mode (water, groundwater, soil, or air) by which a chemical moves through the environment.

PEL: Permissible exposure limits, workplace exposure limits established by the Occupational Safety and Health Administration (OSHA).

Persistent chemical: A substance that resists biodegradation and/or chemical oxidation when released into the environment and tends to accumulate on land, in air, in water, or in organic matter.

Planned removal: The removal of released hazardous substances from the environment within a nonimmediate, long-term time period. Under CERCLA, actions intended to minimize increases in exposure such that time and cost commitments are limited to 6 months and/or $1 million.

Pollutant: A substance or mixture that after release into the environment and upon exposure to any organism will or may reasonably be anticipated to cause adverse effects in such organisms or their offspring.

Pollutant transport: An array of mechanisms by which a substance may migrate outside the immediate location of the release or discharge of the substance—for example, pollution of groundwater by the migration of hazardous waste from a landfill.

PSD: Prevention of significant deterioration, regulations that were established by the 1977 Clean Air Act amendments to limit increases in criteria air-pollutant concentrations above baseline.

Qualified individual: A person who through education, experience, or professional accreditation is competent to make judgments concerning a particular subject matter. A certified industrial hygienist may be a qualified individual for preparing a site safety plan.

RACT: Reasonably available control technology, the recommended level of emission controls applicable to some sources located in nonattainment areas requiring revisions of state implementation plans.

Regulated material: A substance or material that is subject to regulations set forth by the Environmental Protection Agency, the Department of Transportation, or any other federal agency.

Remedial actions: As in the National Contingency Plan, responses to releases on the National Priority List that are consistent with permanent remedies to prevent or mitigate the migration of a release of hazardous substances in the environment.

Reportable quantity: As set forth in the Clean Water Act, the minimum amount (pounds or kilograms) of a substance that may be discharged in a 24-hour period that requires notification to the appropriate government agency.

Response activities: Activities taken to recognize, evaluate, and control an incident.

Response operations: See Response activities.

Risk: The probability that an unwanted event (harm) will occur.

Risk assessment: The use of a factual basis to define the health effects of exposure of individuals or populations to hazardous materials and situations.

Risk management: The process of weighing policy alternatives and selecting the most appropriate regulatory action integrating the results of risk assessment with engineering data and with social and economic concerns.

Route of exposure: The manner in which a chemical contaminant enters the body (e.g., oral, inhalation, cutaneous, or parenteral).

Safety: Freedom from human, equipment, material, or environmental interactions that result in injury or illness.

Sampling: The collection of a representative portion; For example, a water sample from a contaminated stream.

Second responders: Those personnel required to assist or relieve first responders at a hazardous-material incident due to their specialized knowledge, equipment, or experience. These can include state environmental-protection or health officials, commercial response and cleanup companies, and appropriate industry representatives.

Severe: A relative term used to describe the degree to which hazardous-material releases can cause adverse effects to human health and the environment.

SIP: State implementation plans, requirements set forth by the Clean Air Act for states to develop plans and programs to achieve and maintain NAAQS.

Site: Location.

Site safety plan: Written site-specific criteria that establish requirements for protecting the health and safety of responders during all activities conducted at an incident.

Third responders: Those personnel required to help the first or second responders handle special situations or to conduct the cleanup, removal, and associated activities. These can include federal environmental-health officials, other federal agencies, commercial response and cleanup companies, and appropriate industry representatives.

TLV: Threshold limit values, the recommended concentrations of airborne contaminants to which workers may be exposed according to the American Council of Governmental Industrial Hygienists.

Toxic air pollutant: Any potentially hazardous noncriteria air pollutant. Criteria pollutants include: carbon monoxide, oxygen, suspended particulates, and lead. .

Toxicity: The ability of a substance to produce injury once it reaches a susceptible site in or on the body.

Work plan: Written directives that specifically describe all work activities that are to take place at a work site.

Z list: OSHA list of hazardous chemicals (29 CFR 1910 Subpart Z, Worker Right-to Know).

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Numbers in italics refer to figures